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PUBLIC HEALTH PROBLEMS.

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BY

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PART III.

DEFENSIVE MEASURES AGAINST COMMUNICABLE DISEASES.

PREFACE.

INCREASING knowledge of the inimical factors acting upon the health of communities, and the application of practical measures for the prevention of disease, have given rise in recent years to many interesting problems that are passing through various stages of solution. In this volume an attempt has been made to bring to a focus some of the essential points in evolution, environment, parasitism, prophylaxis, and sanitation, bearing upon the preservation of public health. The scope of the subject is necessarily wide, but the central point round which its treatment has gathered is the aspect presented to a health officer in reviewing the influences operating around him. I am only too conscious that my work falls short of completeness, but the reader will realise that the complexity of the task conveys also an idea of the ramifications and intricacy of the problems dealt with by workers in the public health service.

Statistics have been avoided as much as possible; my endeavour has rather been to cast a reflective and suggestive line of thought into the volume, perhaps

at the sacrifice of some detail in parts, on account of the gaps that observation and research have not yet filled. With the materials available, it became apparent that a clearer idea of the future drift of many public health questions might be obtained by tracing the phases through which they have passed to emerge into their present light. It may be objected that, in reference to sanitation, only the particular points relating to the dwelling have been touched upon, but engineering questions have been purposely avoided with the object of throwing into relief more elementary principles, especially in reference to light and air, which are so persistently neglected, but which are such important factors in influencing the health of large urban populations.

I am greatly indebted to Mr. Havelock Ellis for much valuable advice given at appropriate moments in the course of the manuscript, and I must express my thanks to Dr. John Glaister for carefully reading and annotating the proof-sheets with suggestions whilst the book was going through the press.

J. F. J. S.

40 Camden Square, N.W.,
September 1892.

PUBLIC HEALTH PROBLEMS.

INTRODUCTION.

"For life is not to live, but to be well," said Martial, who lived in the first century, when Rome was in the full enjoyment of her aqueducts, baths, gymnasia, public latrines, cloacæ, pavements, scavenging systems, and sanitary edicts, so graphically portrayed by Sir John Simon in his *English Sanitary Institutions*. Life has been defined by Herbert Spencer, in his *Principles of Biology*, as "the continuous adjustment of internal relations to external relations," and health is the expression of this response to environment.

Health being, therefore, a relative term, its measure varies, within limits, according to the age, sex, family, and race of the individual, and the physical, chemical, and biological influences surrounding him; and it is maintained by the utilisation of beneficial influences, and by the avoidance, deflection, or suppression of inimical influences. The standard of individual health, when estimated by the physical or intellectual forces displayed, varies more than when measured by the anatomical and physiological gauge, the absence of disease and of disproportion, ascertainable by instruments of precision, being assumed as a negative proof of health. Positive measurements of the proportions of certain structures and functions are already adopted in selecting candidates for the services, for life insurance, and for other special purposes; the anthropometric investigations of Francis Galton and others may be trusted to

supply us ultimately with definite standards of anatomical structure, and physiological function and adaptability.

Like the health of the individual, the health of the community is mainly measured by negative results, the minimum mortality and morbidity; that is, the fewer deaths and the fewer sufferers from disease per thousand per annum of the population, sex, age, and other factors being equal, the healthier the community; the positive measurements being the duration of life, ascertained by constructing a life table of the relative numbers, ages, and sexes of those living and dying during a certain period, and the number of working days available, ascertained by comparing the number, age, and sex of the sick, the nature and duration of sickness, with the number, age, and sex of the population. Statistics of sickness are drawn for the army and navy, in which services accurate records are kept, but the necessary data are not available for civil populations. As in the case of the individual, the physical and intellectual powers developed by communities vary more than the vitality, and are measured by a different class of statistics.

An early allusion to statistics follows from the fact that it is only by this means that standards of structure and function, health and disease, life and death, can become established, and that personal as well as public hygiene is guided by their conclusions.

Statistics are based upon the census enumeration, within a given area, of the number, age, sex, and occupation of the population, and in proportion to these the vitality, mortality, and morbidity are calculated. The vitality is computed upon the marriages, births, deaths, and sickness, the mortality upon the deaths and causes of death, the morbidity upon the nature and duration of sickness, which includes both injury and disease, and upon the number, age, and sex in each class.

These data are obtained from the registers of marriages, births, deaths, and sickness, the causes of death and nature of sickness being obtained by medical diagnosis, and upon the skill of an educated medical profession ultimately depends the accuracy of all mortality and morbidity statistics. It is very apt to be treated lightly, or to be overlooked, that the prevention of disease amongst a people is fundamentally

dependent upon an educated medical profession, trained both in practice and experiment.

Experiment as well as statistics form the groundwork of hygiene in all its ramifications. The science, which was born with the rudiments of civilisation, has increased in growth *pari passu* with scientific and social development, and has put forth many branches. Personal and public health meet at many points in the various branches of hygiene, domestic, scholastic, and occupational, naval, military, and civil, urban and rural, national and international, built upon many sciences by many professions, but divisible broadly into the causation of disease and its prevention. Etiology, or the causation of disease, is the offspring of medicine, and the indications for disease prevention have greatly stimulated the study of the collateral sciences.

The efforts of the individual in the preservation of health are limited, and the advice of Pythagoras to find out that course in life which is best, and then habit will render it the most delightful, is followed with difficulty even by the most favoured individual. How much fewer, then, must be the opportunities possessed by the least favoured amidst the stress and turmoil of providing for existence under modern industrial conditions? The training of the young in bodily and mental exercises and healthy habits, coincidentally with education in the accumulated experience and knowledge of preceding generations, rapidly bridges over the wide gulf of time that unaided individual effort would require to find the best course.

The slow processes of nature, if capable of coping with segregated rural conditions, are outstripped and overtaxed by the aggregation of communities in limited areas, every individual of which is dependent upon his neighbour for the condition of his surroundings. Not only does communicable disease readily settle and extend in concentrated populations so as to necessitate public measures of prophylaxis, but conditions are established that cause deterioration and degeneration, rendering the inhabitants a ready prey to other diseases, and requiring measures of sanitation for the maintenance of health. The science of public health is not content with the suppression of communicable disease, but aims rather at securing those conditions of the health

of a community that shall enable it to display the utmost activity of its physical and intellectual energies. It must be admitted that this conception of the task is somewhat extensive; nevertheless, however far it falls short of its realisation, it is a labour worthy of the many workers contributing from various sources to its accomplishment.

Public health problems, formulated by medical, biological, and scientific evidence, involve legislative, administrative, and social changes of the widest extent in their solution. The social element is a factor to be largely reckoned with. State remedies cannot be applied in advance of public opinion, and this is slow to move. The education of a vast community is perhaps the most difficult task that falls to sanitarians. Persuading the unscientific mind to reason logically, even after possession of the facts, is not a light task. To rouse it to take action, even when convinced, and to overcome prejudice, requires a prodigious effort. Cremation makes but slow advance, scarcely recognisable. Muzzling of dogs, as a measure for the prevention of hydrophobia, raises the antipathy of those who are concerned more for the canine species than for their fellow-men. The opposition to experimentation upon animals by man, whilst nature herself is hourly experimenting upon human beings; the opposition to vaccination mainly because it is compulsory, and in disease attributed to its influence *post hoc* is not distinguished from *propter hoc;* the opposition to the suppression of sexual disease in garrison towns because of the failure to appreciate the fact that the State practically endeavours, and fails, to impose celibacy upon a large body of men, without attaching the moral restrictions of a priestly calling, or imposing the physical barrier of emasculation :—these things must surely bring to the lips of the legislator the words of Galileo, *E pure si muove.*

Modern pathology seeks far back for causes of disease. Heredity and the effects of internal influences upon the health of the individual and the community have their place, and not an unimportant one, in public health problems. External influences are traced a step further than was considered necessary in former years; their effects upon other forms of organic life which react upon man must be included in the hygiene of the future.

But the special feature that is rapidly changing the aspect of pathology is the study of the communicable entities of contagia, and all future work in infectious or contagious diseases will be based upon a parasitic theory. Our knowledge of these diseases is increasing so rapidly in exactitude, and extending so widely in scope, that it is difficult even for experts to keep pace with the advances of scientific research all along the line of micro-biology.

Since the discovery by Pasteur of the method of growing bacilli outside the living body, followed by Koch's discovery in 1880 of the mode of separating species of microbes by cultivation on the surface of solid media, and again followed by his discovery in 1882 of the tubercle bacillus, and the complete proof of the parasitic nature of an infectious disease in man, the progress of bacteriology has advanced, comparatively speaking, in a geometrical ratio, and a host of observers have been at work recording observations upon communicable diseases among plants, animals, and man.[1]

The burning questions of the hour in general biology are the variations that organisms, complex and simple, are subject to under changed environment, and the transience or permanence of these variations. The equally important problems in micro-biology are the attenuation and intensification of the virulence of micro-organisms under varying conditions, and the immunity naturally existing, acquired, or artificially produced, against diseases in man and animals due to such microbes. The outcome of researches in this new branch of the science of micro-pathology, by explaining adaptation and variation, will in the future throw a clearer light upon the greater issue of heredity.

The growth of the organisation that in this country has enabled the researches of pathology to find practical application in preventing the spread of disease dates back to the commencement of civil registration in 1837, and the work of Farr, Chadwick, and Simon in statistics, investigations,

[1] In this direction human pathology is being supplemented by the publications of the Veterinary and Intelligence Departments of the Board of Agriculture, that record the origin, prevalence, and extension of contagious diseases among animals and of destructive parasites among plants.

and administrative measures, continued by the Registrar-General's office, the Local Government Board, and the Local Sanitary Authorities to this day. Thus the revelations of more recent pathology find a complete organisation at hand for the practical application of measures indicated by scientific research. The value of this is expressed by the progressive fall in the mortality of this country.

The methods of prevention, and perfection in the measures adopted, are following closely in the footsteps of research. It is becoming a matter of past history how plague and, to a certain extent, cholera have been driven back out of Europe, and other infectious diseases promise to follow in their wake. Relapsing fever and typhus epidemics are less frequent visitants than formerly, and not only is the mortality from other zymotic diseases being reduced, but the general mortality of this country, and especially that of the great centres, has fallen in recent years in a marked degree. This is acknowledged to be due to the organisation of the public health service of this country, and to the prophylactic and sanitary measures indicated and executed.

A still greater work has been, and is being, accomplished by this service in the powerful educational effect, not upon the young so much as upon the adult population, resulting from the continuous work of the large body of health officers and sanitary authorities.

Public Health in its later developments has realised that it could never hope to satisfy its aspirations by the prolongation of the existence of the more favoured members of the community. Its greatest justification lies in increasing the health and power of the workers, and especially of the industrial classes, those less able to help themselves. It is distinctly socialistic in its tendencies as distinguished from individualistic; it is, in the widest sense, humanitarian. The nation that makes some effort to assist a neighbouring nation in minimising the evils of famine and war, even at some sacrifice of patriotism, may reap the reward by averting an epidemic, inhibiting it at its birthplace, just as a smaller community may protect one adjoining, or an individual his neighbour.

It is well-nigh impossible to form an adequate conception of the problems involved in defending the health of a

population without having in mind the various elements that undermine and overpower it. First amongst these, and introduced at birth, are the questions that hover around heredity and the potential effects of intrinsic characteristics upon the future of the being. The physical, chemical, and biological influences external to the organism follow in natural sequence. But in considering the effects of these influences, when they produce injurious or prejudicial results, the order of priority is reversed by practical social conditions, communicable diseases due to biological causes claim the first attention, and prophylactic measures for their suppression take precedence in the health administration of a community. Injurious chemical and physical influences, though not less important, demand more time for their rectification by requisite sanitary measures. The two classes of remedial effort act from opposite standpoints, the former attacking disease, as it were from the rear, by suppressing it in its track, the latter advancing towards humanity equipped with a knowledge of the requirements of healthy existence, and securing their provision.

Such is an outline of the ideas to be conveyed within the limits of this volume, but as to sanitation, it will only be possible to touch upon the main points as they present themselves amongst an urban population, especially in reference to the dwelling; nothing short of an encyclopædic work could encompass more.

PART I.

THE EFFECTS OF INTERNAL AND EXTERNAL INFLUENCES UPON HEALTH.

CHAPTER I.

HEREDITY.

THE Darwinian theory of natural selection has given prominence to two schools of evolutionists, the one attributing evolution solely to selection, and the other, whilst not denying the effects of selection, valuing—perhaps over-valuing—the effects of heredity. The difference of opinion may in a measure arise from difference in the methods of treating the subject, partly also because of the varied limits of the meaning attached to terms, but greatly from the present insufficiency of our knowledge. The one school is mainly deductive, and the other inductive in method. Weismann may be taken to represent the former, and Herbert Spencer the latter. Darwin himself retained the older Lamarckian theory of heredity to explain those facts of evolution not explicable by selection.

The theory of natural selection is based upon certain fundamental principles, the power of rapid multiplication of organisms in geometrical progression, the struggle for existence which follows, and the survival of those organisms whose variation is fittest to cope with their environment, no two organisms being identically similar, although bearing a general likeness to their parents and to each other.

So far there is no divergence of opinion, but the origin

of variation is the rock on which the two schools split. The deductive school maintains that the sole source of the variation is the intermingling of the varied sexual elements of the parents, and that characters acquired by the individual are not hereditary. The inductive school, proceeding from the opposite end of the pole, argues that the influences of environment act upon structure through function, that function is modified by adaptation to environment, and that "adaptive change of function is the primary and ever-acting cause of that change of structure which constitutes variation."

It is as well to be clear as to the meaning of the terms "variation" and "adaptation." It is admitted that the type is hereditary, and that the variation which by natural selection survives is hereditable—in short, that variation is a congenital modification, existing or potential. The term "adaptation" is not used in an equally definite sense. There is an adaptation taking place in the individual (Spencer's direct equilibration), and adaptation of the species (Spencer's indirect equilibration, and he points out that this is identical with that process of survival of the fittest which Darwin named "natural selection"). Weismann only recognises the term as applicable to the species, against which Eimer protests. Therefore, in referring to the opinions of the inductive school, it is advisable to understand the term as mainly applying to individual adaptation.

The inductive school holds that environment may induce adaptation, but that the limit is soon reached, is very slowly extended from generation to generation, and acts at the same time as the influence of heterogeneity of progenitors in producing variation.

The deductive school of Weismann holds that variation is produced solely by the mixture of the characters in sexual reproduction, the germ-plasm being of extraordinary complexity. Whence is this complexity derived? In a complex organism the individual is more or less dependent upon the structure and environment of the separate organs, and these organs again upon the structure and environment of their separate cells. An ultimate analysis of each separate organ, and of each separate cell, will bring us to that stage in its development in which its existence must depend entirely

on its adaptation to some definite purpose or condition of existence. Geddes and Thomson, in *The Evolution of Sex*, whilst regarding sexual selection as a special case of natural selection, have penetrated more deeply into the origin of variation in their search for the origin of sex, and trace it to the differentiation produced by the constructive and destructive metabolism of the organic cell—the anabolism and katabolism of protoplasm.

But whether acquired characters are or are not hereditable is a fundamental question. Weismann maintains that the characters themselves are not, but that the predisposition to characters acquired by the individual is hereditable. Galton holds that characters acquired by the individual as the result of external influences cannot be inherited, unless such influences act on the reproductive elements, and Wallace holds the same view.

The characters possessed by an individual are either congenital or acquired. The congenital characters peculiar to each individual are the type and the variation. The offspring bear a typical likeness to the parents, but of the offspring no two are exactly alike, the difference constituting the variation.

The variation must spring from the parents. Whence do the parents derive their potentially or actually transmissible variations? Every animal in its own development rapidly and briefly repeats the history of its ancestors by a process of *recapitulation*. This process explains the perpetuation or recrudescence of organs that have been of functional value to ancestors, and reversion or atavism is due to the repetition of these ancestral characters. These ancestral characteristics in a rudimentary or potential condition are innumerable, and nature, by constantly intermingling and forming new combinations of the hereditary qualities of a vast number of individuals, produces multitudinous variations, upon which natural selection plays.

The tendency of recent work would express itself thus: animals possess such an incalculable number of accumulated potential modifications to call upon for producing variations, that it is difficult, even if necessary, for new variations to gain a footing; and the individual variations apparently transmitted are themselves only combinations or

exaggerations of existing or potential variations. So that the higher the species the less opportunity for the introduction of new characters, and the lower the species the greater the probability of such acquisition. But this does not refute the heredity, even in the highest species, of those combinations or augmentations of characters that appear to be, although they actually may not be, new characters. It only drives the solution of the question back until the ultimate analysis of all the characters of organisms has been propounded. Variations have hitherto been held to be the result in a great measure of use and disuse, but the period of time required to insure the transmission of characters acquired by use appears to be more and more prolonged the further inquiry extends.

Characters acquired during the lifetime of the individual may be produced by injury, or may be the result of adaptation or of disease.

As examples of injury or mutilation may be cited circumcision of male Jews, distorting the feet of Chinese women, docking horses' tails, rupture of the hymen, tattooing, and tribal mutilations. These have been practised for a sufficiently long period to prove that they are not transmitted to offspring. On the other hand, a certain number of instances are recorded of the results of particular injuries appearing more or less distinctly in the next or even several generations, but they are few and far to seek.

The difficulty of adducing satisfactory examples of the hereditability of characters acquired by adaptation to environment is admittedly the cause of the varied opinion upon the subject, and the difficulty of proving the heredity is equally as great. Modification of structure is dependent upon modification of function, function being the expression of the response of structure to environment. The complexity of function is correlative with the complexity of structure, but the differentiation of function precedes the differentiation of structure. By adaptation function accommodates itself to environment, but the limit of adaptation is soon reached in the individual, and very slowly extended in descent, selection and variation in the meantime overpowering the result.

In order to prove absolutely the transmission of the effects of use and disuse, it is necessary to exclude the effeets of natural and artifieial selection. Selection preserves that which is of use and is used, while it eliminates that whieh is useless and is not used; hence the difficulty of producing examples of heredity uncomplicated by variation and selection.

Semper says that every character of adaptation must be in a certain sense hereditary; for if those individuals of a species which first acquired any given character by adaptation were incapable of transmitting it to posterity as a part of their nature—particularly if the exciting cause were to be removed—every newly acquired character would presently be lost. Spencer says it involves denial of the persistence of force to say that the structure of a parent may be changed by alterations of function, and yet beget offspring exactly like those it would have begotten had it not been so changed.

But even Weismann admits the power of unicellular organisms to change in consequence of the direct influence of external agencies, and it is difficult to comprehend how this could be denied to multicellular organisms. He even grants the tendency to new characters acquired during life, and some degree of inheritable influence on the germ-plasm.

Admitting the rapidity and force of the effects of sexual intermingling, of variation of offspring by the erossing of the existing complexity of the parents, and of natural seleetion in securing the survival of the more fit, it does not follow that it is necessary to deny that a parallel process may take place. Such a process, although infinitely slower and less forcible, by individual adaptations may produce differentiations upon which selection also acts, and leaves only the best adapted to carry forward the sexual intermingling and reproduction of the organisms.

Darwin, Spencer, and others give examples of the inheritance of adaptations. The pigmentation of the skin of different races of men, the absenee of eyes in certain cave animals, the large hands of the children of hand-labourers, and the small hands of those long unused to manual labour,

the diminution of the size of the jaw in civilised races, the short-sighted families of watchmakers and engravers. But those who deny the heredity of acquired characters attribute these conditions with equal facility and equal probability to the effects of selection.

Natural selection infers the steady perfecting of equilibration between species of organisms and their environment. This may either be in the direction of ideal perfection elaborating complexity of structure, or in the direction of degeneration, as in the case of the survival of animals with absent eyes in profound darkness, or of parasites with degenerate locomotive, digestive, sensory, and other organs.

Weismann believes that acquired characters are universally understood to be those which arise in consequence of the effect of external forces upon the organism, in contradistinction to those which proceed from the constitution of the germ. But in admitting the possibility that influences continued for a long time, for generations, may affect the germ cells as well as other parts of the organism, and may alter the constitution of the germ-plasm, he admits the possibility of variation produced directly by external influences.

Hence it appears admitted generally that external influences may so impress the germ-plasm as to become hereditary, and therefore the only point at issue is the duration and intensity of the external influences required to produce the impression.

The most extreme effects of use and disuse frequently evince themselves as acquired disease, and hence, as may be expected, the strongest evidence of the heredity of acquired characters is found in pathology. Pathological modifications follow the same laws as physiological modifications. The two processes are the same, the physiological extending to the limit of adaptation of the individual, the pathological passing beyond it, leading to disease, and ultimately to death. Hence the extent, intensity, and duration of pathological processes produce greater effect upon the germ-plasm than physiological, and tend to be more readily inherited.

The more recent experiments upon micro-organisms

tend to show that among organisms whose life-period is short, and in which generation succeeds generation rapidly, the tendency is to acquire and apparently transmit characters not previously possessed. Organisms have been cultivated up to the point of flourishing in a high temperature, so high that uncultivated organisms from the same stock have quickly succumbed to it. Acclimatisation is an analogous phenomenon, but not so rapidly effected.

Experiments of recent years upon the lowest forms of life tend to show that considerable variation may be produced in the functions of micro-organisms, which variations may be maintained, and even accentuated, provided the conditions of environment producing them are sustained. It is therefore probable that it will ultimately be proved that the perpetuation of variation will depend upon environment as much as upon selection, but that as the scale of organic life is ascended, the resultant effects depend less and less upon environment, and more and more upon selection. For this reason, that whereas the variation in a simple isolated cell is easily brought about, and is confined to the unit, in a complex organism one cell or one class of cells cannot vary in any degree without upsetting the balance of the entire organism, and so bring about its destruction on account of the immense revolutionary change required in the rest of the organism to restore the balance, and bring the other classes of cells into equilibrium with the varied unit or class.

In the inheritance of modifications produced by increased use evils appear to be transmitted more strongly, and more quickly, than benefits, because pathological modifications are more extreme efforts of adaptation than physiological, and pass beyond the normal limits of individual adaptation. Selection, therefore, should eliminate this pronounced form of use-inheritance, but amongst civilised man this effect of natural selection is artificially retarded, allowing sufficient time to elapse for the reproduction and inheritance of pathological tendencies, although ultimately the effect of selection may be extinction.

It is not denied that the effects of excessive use

or disuse may be transmitted, and injure or deteriorate the reproductive elements. Such deterioration in the parents may produce a general lowering of the vitality of the offspring, and might be explicable on the general ground that weakly parents cannot beget robust offspring, the germ-plasm sharing the deterioration equally with other structures and functions. But it does not explain why a particular system, organ, or function in an otherwise robust individual should possess the particular predisposition to a disease that the parents acquired.

The term "predisposition" is used advisedly, for pathological modifications are not transmitted to the same degree as they exist in the parent; the offspring does not inherit the disease itself, but the predisposition thereto, or the diathesis. Infants are not born gouty or diabetic, or epileptic or insane. The only forms of actual disease recognised as true congenital diseases are malformations and zymotic diseases. The former being structural variations, the latter being the symptoms of the presence of micro-organisms transferred to the offspring, as tuberculosis, syphilis, etc.

Excluding injuries and zymotics, acquired disease may exist only temporarily or may become permanent in the individual. The less vital the part or parts affected, and the less the extent and duration of the abnormal function, the less probability of the offspring being impressed. On the other hand, the more vital the part affected, and the more intense, extensive, and prolonged the abnormality, the greater the probability of producing hereditary effects. Excessive use of the nervous system of the parent more readily produces an effect upon the offspring than excessive use of the locomotive system, and the greater the extent and duration of the resulting disease in the parent the greater the predisposition in the offspring.

Chronic disease is more liable to impress the offspring with an inherited tendency than acute disease. When the disease is permanent it essentially consists in abnormality of structure, the result of abnormality of function, or, in other words, it becomes constitutional, and the type of constitution or diathesis is hereditable.

The hereditability of the constitution is exhibited in its

highest degree in the permanence of race characteristics under changed external influences. The vitality of the Jewish race, apparently acclimatised in most parts of the civilised world, remains undiminished. At the last American census 10,618 completed family schedules were returned, numbering 60,630 persons, and recording 2148 marriages, 6038 births, and 2062 deaths during five years, the average death-rate being 7.11 per 1000 of persons living, equal to about one-half the rate for the general population. The expectation of life at ten years of age in 1889 was 61.11 years for males, and 56.02 for females, as against 46.99 and 48.05 for the general population.

Some diseases also are peculiar to race just as others are peculiar to individuals—that is, there appears to be also a congenital race susceptibility and immunity. Negro lethargy is purely a disease of negroes. The same race also exhibits a certain immunity from yellow fever, a disease to which the white races are specially susceptible, until acclimatised. It is not possible to dogmatise on this point, for other factors may prevail, such as locality, the presence of an endemic microbe, and the acquisition of immunity in infancy. Sex and age are recognised as materially affecting susceptibility to disease, and the resultant mortality. It is a general law that mortality is very high at birth, reaches a minimum from ten to fifteen years, and, again, slowly but steadily increases through the remaining life-period.

The constitution or diathesis may be more or less susceptible to disease, and this susceptibility may be acquired or inherited. Acquired, as in the case of diseases attacking and recurring in the individual, such as nasal, laryngeal or bronchial catarrh. Inherited, as exemplified by the special tendencies exhibited by particular families to particular diseases, such as gout, rheumatism, and zymotic diseases.

Insusceptibility may also be acquired or inherited. Acquired, as in the *natural immunity* against a second attack produced by certain of the zymotic diseases, and the *artificial immunity* produced by inoculations and vaccination. Inherited immunity is less readily exemplified, and in the case of zymotic diseases is so feeble or so rare, that if selection alone were trusted to secure the survival of

those hereditarily immune, the result would be the decimation of the human race. Modern hygiene is so impressed with this vital fact that the highest efforts of research are eagerly bent upon discovering methods of procuring artificial immunity, to displace the fatal risks incurred in obtaining natural immunity, from zymotic diseases.

It is of the greatest moment to public health to estimate the relative value of the transmissibility of acquired characters, and of the effects of selection, natural and sexual. Can rearing, training, and mode of life counteract the effect of unwise sexual selection, and convert a physically unfit product of such a union into a physically fit? Can such an effect, if produced, be transmitted to descendants, and become lineally established within measurable time? Even if it be established that species have been evolved through countless ages by adaptation, as well as selection, it is no solution of the pressing problem of the more immediate effects of adaptation upon the offspring and descendants.

The structures and functions of the individual can be improved by exercise and training, for use, within limits, enlarges and strengthens, but it is also the main determining factor of selection. If use-inheritance be one of the factors of evolution, it is so overpowered by the more immediate influence of selection, that owing to the difficulty of disentangling it from more powerful factors, proof of its beneficial effects appears unattainable. The condition of survival is fitness; and although the adaptation of the individual may enhance the chance of survival, it does not demonstrate its power of transmission until adaptation be extreme, and be so strongly pronounced as to jeopardise the health, if not immediate existence. Then selection commences where adaptation ceases.

Mr. Platt Ball, in his recent publication on *The Effects of Use and Disuse*, asks:—"How, then, can we rely upon use-inheritance for the improvement of the race? Even if it is not a sheer delusion, it may be more detrimental as a positive evil than it is advantageous as an unnecessary benefit; and as a normal modifying agent it is miserably weak and untrustworthy in comparison with the powerful selective influences by which nature and society continually

and inevitably affect the species for good or for evil. The effects of use and disuse—rightly directed by education in its widest sense—must of course be called in to secure the highly essential, nevertheless *superficial, limited, and partly deceptive* improvement of individuals, and of social manners and methods; but as this artificial development of already existing potentialities does not directly or readily tend to become congenital, it is evident that some considerable amount of natural or artificial selection of the more favourably varying individuals will still be the only means of securing the race against the constant tendency to degeneration which would ultimately swallow up all the advantages of civilisation. The selective influences by which our present high level has been reached and maintained may well be modified, but they must not be abandoned or reversed in the rash expectation that State education, or State feeding of children, or State housing of the poor, or any amount of State socialism, or public or private philanthropy, will prove permanent substitutes. If ruinous deterioration and other more immediate evils are to be avoided, the race must still be to the swift, and the battle to the strong. The healthy individualism so earnestly championed by Mr. Spencer must be allowed free play. Open competition, as Darwin teaches, with its survival and multiplication of the fittest, must be allowed to decide the battle of life independently of a foolish benevolence that prefers the elaborate cultivation and multiplication of weeds to the growth of corn and roses. We are trustees for the countless generations of the future. If we are wise we shall trust to the great ruling truths that we assuredly know, rather than to the seductive claims of an alleged factor of evolution for which no satisfactory evidence can be produced."

This is admirable as a plea for individualism, but many will take exception to the estimate of education, especially of that form which contributes to the knowledge and growth of the individual in the preservation and transmission of health.

Doubtfully possible as it may appear to be to render the fit by adaptation from one generation to another more fit, or the unfit ultimately fit, the converse requires no proof;

the fit may readily become unfit, fall a prey to degeneration and disease, and reach a condition beyond remedial measures.

Amongst animals in a state of nature, selection has full play; but although the control over his environment may in a measure enable man to modify the process of selection, he cannot escape from its ultimate effect. The tendency of civilised communities is to reduce the severity of the process of elimination, and by humane efforts to smoothe the path of the unfit.

Both in a savage and a civilised community the members must vary in fitness from the most fit to the most unfit. As the most fit must in the struggle always tend to survive, and the most unfit tend to be eliminated, it follows that, whether acquired characteristics are hereditary or not, selection must be constantly at work, adapting the community to its environment in accord with or in despite of heredity.

Sir John Simon, in his work on *English Sanitary Institutions*, meets the point in its practical aspect thus—"The educated spectator who contemplates in mass the toils and sufferings of the very poor, as exhibited on so terribly large a scale among the least-earning classes of the population, will not fail to apprehend the *biological* meaning of what he sees. It is hardly a figure of speech to say that he has before him, as in latter-day form, the still-continuing aboriginal struggle of mankind for existence, and is informed by the samples he beholds that hitherto, even where general progress is most advanced, a considerable proportion of the strugglers have attained but an imperfect and precarious success. Not in any apathy of fatalism, but, on the contrary, with the most definite regard to methods of treatment, the ruler who would deal on a large scale with the relief of poverty must always in due regard remember that evolutionary aspect of the case—must remember that he is not unlimited master in a province of exclusively human institutions, but is to some extent face to face with the inexorable laws of nature; and that nature (as Lord Bacon teaches) *non nisi parendo vincitur*."

The advance of our knowledge in biology emphasises firstly, the superlative importance of sexual selection, to

secure that the fit may be born; and secondly, the value of prevention, that the fit may not become unfit.

Sexual selection has been practised artificially by pairing animals from remote times, but especially within the last hundred years; breeders of animals have contributed materially to our knowledge of facts, and we owe the present high qualities of our cereals and plants, as well as of our animals, to the process of careful selection.

There are defined limits to the power of improvement by breeding, although the near and remote consequences may not be reducible to exact laws. Breeding may take place by in-breeding, cross-breeding, and hybrid-breeding, according to the relationship of the individuals pairing.

It depends very much on the significance attached to these terms how the results are estimated. In-breeding, carried to the extent of pairing in the closest degree, as between the offspring of the same generation, derived from the same parents, is more aptly called in-and-in-breeding; but when the pairing is between less closely related individuals, it is more appropriately termed inter-breeding. In the same manner cross-breeding may take place between individuals of similar, although distinct, breeds of the same species, and also between individuals of very dissimilar breeds, or individuals of similar breeds acclimatised in widely dissimilar localities. Darwin has already pointed out the parallelism of the effects of crossing with the effects of changed external physical conditions. These two extremes of cross-breeding may be characterised as moderate cross-breeding and extreme cross-breeding. Hybrid-breeding is held to apply to the pairing of individuals of different species.

In-breeding is a process affording great facility for emphasising any particular quality; efforts to develop rapidly or to extreme limits any special quality being made by the sacrifice of some other quality or qualities. Strength and endurance in race-horses are sacrificed to high speed. Fineness of wool in the merino sheep is obtained by the sacrifice of size and vigour through confinement to the house.

The closer the relationship of the animals possessing a special characteristic, the more it is emphasised, and the more fixed it becomes. But in-and-in-breeding in close

consanguinity leads to other qualities being sacrificed to one particular quality to such an extent as to result in destroying the very basis from which it is derived, conducing to monstrosity, disease, or infertility.

The more gradual the stages of improvement the more permanent it becomes, the more certainly it is transmitted, the more vigorous the breed, and the less liable to lead to infertility by monstrosity or by the production of only one sex. Thus inter-breeding, by retaining the characteristic of the breed, leads to its more certain perpetuation than close in-and-in-breeding, which ultimately compels the breeder to cross the breed in order to save it from extinction by the intensification of hereditary taint or the failure to reproduce both sexes.

In cross-breeding, when breeds are similar, the crossing produces a levelling of special characteristics, but increased vigour and fertility. In extreme cases, when breeds are too dissimilar, irregular variations take place, relapsing to former types by reversion or degradation, and leading to diminished fertility. Darwin pointed out that judicious crossing is of great value in removing inherited tendency to disease.

In hybrid-breeding, or the pairing of distinct species, without necessarily defining species and varieties, it may be generally said that the offspring is either sterile, or, if fertile, the fertility is diminished, and the progeny return to the type of either of the progenitors—*e.g.*, the hybrid of the ass and the mare, the mule; the hybrid of the goat and the sheep; the hybrid of the hare and the rabbit, etc. Much information on hybridity from opposite points of view is to be found in Wallace's *Darwinism* and Quatrefages' anthropological introduction to the *Encyclopédie d'Hygiène.*

So that on the one hand extreme in-breeding leads to the emphasis of special characters, and ultimately may lead to monstrosity, degradation, and infertility; on the other, extreme out-breeding (so to speak), if not cut short by immediate sterility, may lead to reversion, degradation, and infertility. The evil results of close in-and-in-breeding can only be avoided by the most rigid natural and artificial selection, and in a similar manner the infertility can be modified.

The middle course, that of judicious cross-breeding, leads

to increased vigour and fertility, but in any case selection in pairing is the most important factor.

Practical breeders of animals trust to the selection of fit animals, and not to the training of the unfit and indifferent to maintain or improve their breeds—a practical illustration of the value of selection compared to adaptation.

Marriages are governed rather by the present considerations of the uniting pair than by the future welfare of the offspring. To benefit the family and the community a process of sexual selection, in the expectation of the production of healthy and vigorous offspring, is necessary. This matter is of national import; and although largely social in its bearing, public health cannot fail to take cognisance of the results upon the health of the community. In this aspect it affects the whole nation.

Restrictions upon the number of partners permissible by social custom or legal enactments have narrowed down the limits from promiscuity, through polyandry and polygamy, to monogamy. More or less parallel with this, prohibitions in the relationship of the individuals uniting have proceeded from incest through first, second, and third degrees to more widely distant degrees of relationship and affinity.

Huth, in his interesting work on *Marriage of Near Kin*, concludes that, as too great restrictions on marriage give an impulse to immorality, and immorality is directly and fatally injurious to the community, it is inadvisable to extend the prohibition against marriage beyond the third collateral degree, and desirable to permit all marriages of affinity excepting those in the direct ascending and descending line. He does not believe that marriage of consanguinity *per se* necessarily creates disease, but, in accord with the experience of breeders, admits the intensification of idiosyncrasies by in-and-in-breeding. No man possesses perfect health, nor can be said to be absolutely free from constitutional taint. Similar idiosyncrasies will be more probably found in individuals of the same family than in individuals of different families, and the more similar the more closely they are related. It is admitted that the same quality in both parents tends to be intensified in the offspring, and so it is more probable that if the quality be morbid the offspring of closely related parents will suffer.

But if close consanguineous marriage be accompanied by intensification of risks to the offspring, so also in the other extreme, marriage between individuals of widely different races exhibits evil results by reversion, and the production of degenerate half-castes, with the ferocity and depravity of their savage ancestors.

If the union of individuals possessing like morbid characteristics, and their consequent intensification be the danger of consanguineous marriages, and not the consanguinity *per se*, it follows that the union of individuals possessing like morbid diatheses, whether related or not, is of far greater importance than mere consanguinity.

That hereditability of predisposition to morbid changes exists, and that the chances of transmission are increased if both parents possess similar morbid conditions, is undeniable. The indication therefore is that, apart from consanguinity, the family history of health and disease should form the guide to sexual selection. Francis Galton's researches have emphasised this value of pedigree or family history.

The earliest consideration before marriage should be the possible fitness of the probable offspring, and the power and means of maintenance, rearing, and training of the family. State-regulation cannot control this, for restrictions placed upon marriage only serve to divert into immorality.

It has been held that it is the duty of the State to prevent reproduction of its unfit members, even to the extent of suggesting the emasculation of criminals. Who shall say that it is heredity rather than environment that produces the criminal? Selection is so overpowering, and so all inclusive of cause and effect above the judgment of man, that only nature herself can be the just judge of the fittest.

Even compulsory life insurance, accompanied by medical examination, previous to marriage may fail to reveal personal predisposition or family tendencies. But besides the family history and the previous health of the parents, their condition also at the time of union, and the condition of the mother during gestation, are equally important in their results upon the health of the offspring. It would appear almost hopeless to control so many factors by any

other means than the action of the individuals immediately concerned.

The only method by which the avoidance of errors in marriage can be obtained is by the cultivation of the knowledge of those natural laws which, if disregarded, infallibly bring disease and death to the progeny, and misery and despair to the parents. It is in instruction in the laws of health, rather than in the many panaceas at hand, that the safer, more certain, and more permanent means lie by which the birth of the fit may be secured, and the individual may be prevented from becoming less fit through a course of life, the evil effects of which upon himself, his partner, and his offspring he is ignorant of, or cannot appreciate.

When prevision shall have become a characteristic of the many, and prescience be the guiding principle of conduct, when it shall have become an infringement of the moral and social code for individuals to marry blindly without knowledge of their predispositions, mental and physical, and without thought for future offspring, then, and then only, will due care be exercised in the production of the offspring that is to succeed and carry onward the nation to subsequent generations. This time will only arrive with that prescience which follows upon the knowledge acquired by education.

Equilibrium may be established between the individual and the environment, either by the adaptation of the structures and functions of the individual, or by the modification of the environment. In either case the adaptation is dependent upon the individual; in the former it is direct, in the latter indirect. The limit of adaptation of the individual is reached much sooner than the limit of modification of the environment.

The variations of environment have a far wider range, and may be more rapid, than the capacity of the individual to adapt himself to them. It is the range and flexibility of the direct adaptive power of the individual that is the measure of health under adverse external conditions. But the sum-total of the power of adaptation displayed by the individual must include also that power to avail himself of or cause, those modifications of external influences which

enable an equilibrium to be established between himself and his environment, such as climate and locality, conditions of life and habits, occupation, and many other relations. The man whose lungs in a cold, dry climate may act disadvantageously, may betake himself to a warm, moist climate, there find a more congenial atmosphere, and not only his present health be improved but his life prolonged, provided that he possess no special susceptibility to those new external influences, or combination of influences, found in the climate or locality chosen. Again, the individual whose power of adaptation to varying temperatures is small or diminished, may, by wrapping himself in woollen clothing, or by other means, indirectly adapt himself to external influences.

The indirect power of adaptation extends beyond the individual, and its effects are far-reaching, in enabling the individual to choose the ideally fittest partner and co-parent. An ideal of some kind is necessarily possessed by every one, but no means are adopted to enable a fit ideal to be formed. This ideal is all-important to the future generation, and the endeavour to attain it instils that prescience and providence which are the basis of human progress. Yearning to know the future is a human characteristic that too easily leads to superstition, but whatever fear of it existed in the past is scarcely justified in the present. It is no longer gauged by the positions of the stars, or the entrails of animals, but science enables many an effect to be foreseen as the result of known causes. Prevention is dependent upon the knowledge of cause and effect. Any hope of amelioration in the fitness of the generations yet to be born must be dependent upon the acquisition of this knowledge by the present generation, the parents of the future. The process of sexual selection itself must be submissive to the power of the individual capable of selecting a mate adapted to counteract injurious, or to supplement deficient, characteristics. Indirect as it may appear, the individual possesses distinct power of adaptation over the offspring.

The weakness of a system, such as the nervous or respiratory, in the one parent may be counteracted by the other, and any neglect to take cognisance of such a weakness on both sides more surely results in disease in the children.

But the power of preventing injury to health, and of cultivating all that is condueive to well-being, important as it is in the parent, is equally important in its application to the infant, the child, and the adolescent.

The attempt of ignorant mothers to adapt the infant to the food rather than the food to the infant, by administering farinaceous gruels instead of milk to babies, exhibits itself in an excessive infantile mortality; the unappreciated necessity to separate the infected from the healthy children frequently results in permanent disease or death; and the neglect of physical conditions during early years renders enfeebled adolescence a ready prey to disease.

Only after extreme and abnormal efforts at adaptation does any sign of hereditability appear. It then only appears as a tendeney in a particular direction. Individual adaptation within normal limits of health produces no appreciable effect on the next or subsequent generations. Those aequired characters and that form of adaptation of the individual which is the result of education show little sign of heredity. The process must be recommenced with each new generation. Each new generation must be warned of the dangers to health encountered by its predecessors, and of the beneficial cffects of measures that have proved themselves favourable to human life by experiment upon individuals from generation to generation, and upon masses of population contemporaneously or simultaneously. Children born amongst civilised communities are not distinguishable from those born amongst savage tribes, by the possession of any intuitive faculties acquired by the education of generations of progenitors. If any effect be produced it is feeble, and must take ages upon ages to produce any discernible result.

Without proper rearing, training, instruction, and practice no child can become, mentally or physically, a fit member of a civilised community. The non-inheritance of acquired habits and customs makes education an absolute necessity of survival in the artificial and complex statc of modcrn soeial communities, education in the art of what to cultivate and what to avoid. It does not necessarily follow that the mere possession of knowledge renders the possessor fit to survive, but it furnishes him with the method of establishing

an equilibrium between himself and his environment, if not with the means.

Counterparts are required in private to the measures adopted in public, that the pursuit of health may become the habit of the individual and the family, and not merely make itself known by so many public buildings. Public baths and washhouses find their supplement in private domestic cleanliness, the fresh air of open space in the improved atmosphere of interiors, public recreation grounds and gymnasia in the bodily exercise of the individual for the pleasure of maintaining health, even the mental exercise of schools in the habit of regularly exerting the mind to mental effort in the acquisition of knowledge and increased flexibility of intelligence within the home.

In the knowledge of natural laws, of the laws of health, obtained by generalised instruction and example, and not by experience or actual experiment in each and every individual, lies the key to the physical improvement of the nation. That small-pox is infectious and fatal, that alcohol tends to incapacitate, that dampness is injurious, and the thousands of established facts which constitute the modern science of hygiene, should not be left to individual experiment. Something more also is required than the mere picking up of scraps of knowledge like odd stones by the way. The maintenance, reproduction, and cultivation of health should regularly form one of the earliest subjects of instruction, and with the growth in the complexity of civilised environment this becomes the more necessary. The closer the aggregation of individuals, the greater the necessity for observance of the laws of health by each particular individual.

There is a tendency to uniformity in health matters, a uniformity based upon natural laws. But it is admitted that the very necessary restrictions and regulations imposed are intolerable to the most ignorant. The constantly reiterated complaint of those familiar with the lives of the lowliest is, "the people themselves are so ignorant of the elements of healthy living." Ignorance is one of the main causes of the origin and propagation of disease. This ignorance in the lowliest is the stumbling-block and destroyer of health in the growth of cities. For the future citizen

the earliest teaching of the school must be how to live healthily and rear healthy offspring.

Herbert Spencer, discoursing upon education, says, "The first requisite of life is to be a good animal, and to be a nation of good animals is the first condition of national prosperity." If there is one subject that should be compulsory in all schools without exception, it is the science and art of living in accordance with the laws of health. The desultory popularisation of sanitation scarcely attains this object. The fundamental principles of private and domestic hygiene are rather the work of the school than of the platform, if effort is to be rightly directed rather than wasteful and possibly pernicious in results.

The plea for general instruction in personal hygiene cannot be too forcibly put. The results, as shown by the general effect upon vitality, would doubtless be considerable, but the greater value would obtain from the right understanding of public health, and the desire to conform to the common weal. It was held for years that the effects of education would by transmission materially compensate for degeneration of race. The denial of the heredity of acquired characters has more recently led to the denial of any hope in the effects of education upon the future generation. There is a strong tendency to degeneration ever present in crowded communities, but if education cannot regenerate the degenerate, it can at least stay the downward progress of degeneration. Education of the mind may directly improve the intellect; education or training of the body may directly improve the physique; but the power and exercise, from the cradle to the grave, of the knowledge possessed of the laws of health, must not only have a preventive effect, but also a regenerative result upon communities enfeebled by the unhealthy conditions of great towns and cities.

Paradoxical as it may seem, one of the pressing *public* health problems of the moment is the instruction of the rising generation in personal and domestic, or *private* health, and its establishment as a compulsory subject in all schools.

CHAPTER II.

PHYSICAL INFLUENCES.

HEALTH being a relative term, its measure varies, not only with the age, sex, family, and race of individuals, but also according to the physical, chemical, and biological influences to which they are exposed. Light and heat, air, water, and soil, and organic life in its multitudinous forms and phases, exert their influences successively and simultaneously in the production or prevention of disease. The complex effects resulting from these variable factors render it difficult to dissociate the influence of one from another; but many careful researches and observations enable the bearings upon health that they individually display to be more or less indicated, and these may be considered *seriatim*—the physical influences, light and heat, claiming first attention.

A certain length of time is necessary for light, or its absence, to produce marked effects upon health. The effects do not demonstrate themselves in any very definite form of disease, but rather as variations in degrees of vitality. The most potent effects are produced indirectly, and are generally immediately attributed to other causes to which they appear in more direct relationships, such as aeration, cleanliness, mental and moral conditions. Observations upon man are few and inexact, and hence, in order to estimate the value of light, it is necessary to pursue the subject somewhat fully in many directions. This is still more necessary, inasmuch as light has in the past been regarded as only of remote influence upon public health, and its effects have not been sufficiently estimated in this connection.

It is a matter of common observation that the leaves and

flowers of plants turn towards the light, and are known to turn away from artificial heat in preference towards sunlight. Another common observation is the vivifying effect of light upon leaves and flowers, causing them to expand under its influence and close as it wanes.

Robert Hunt communicated to the British Association in 1847 his "Researches on the influence of the solar rays on the growth of plants," which were directed to solve the proportion and kind of influence exerted by heat, light, and actinism—as the chemical phenomena of the solar rays are called—in the various stages of vegetable growth. The results to which his experiments led him were:—1. Light prevents the germination of seeds. 2. Actinism quickens germination. 3. Light acts in effecting the decomposition of carbonic acid by the growing plant. 4. Actinism and light are essential to the formation of the colouring matter of leaves. 5. Light and actinism, independent of the calorific rays, prevent the development of the reproductive organs of plants. 6. The heat radiations, corresponding with the extreme red rays of the spectrum, facilitate the flowering of plants and the perfecting of their reproductive principles. In the spring he found the actinic principle, in the summer the luminous and caloric, and in the autumn the caloric, most active.

Mr. Symons, F.R.S., under "Sunshine" in the record of the Royal Botanic Society for the second quarter of 1888, says:—"Without light there is no fructification, and, indeed, few plants can flower without direct sunshine. Under the influence of light plants absorb carbonic acid from the air, the carbon is fixed, and the oxygen is exhaled, a process of nutrition which ceases in the dark. According to Carpenter, Henfrey, Ellis, Garreau, and others, plants also respire continuously night and day, producing small quantities of carbonic acid, formed by the combination of oxygen with their superfluous carbon, a process of combustion which continues in the dark. Thus we see why in high latitudes, where the days are long and even extend into months when the sun never sets, there is almost a quite uninterrupted progress, and that is why growth in those countries is so rapid, and why plants will fructify more rapidly there than in the hotter but shorter days of the south." While this is

the effect of the rapid summers of high latitudes, the continuous absence of light in the winter months produces a most depressing effect upon animal life.

Sunlight is therefore the active force maintaining the purity of the atmosphere, so far as the accumulation of carbonic acid is prevented, by calling into action the compensatory power of the green chlorophyll of plants to split up carbonic acid into carbon and oxygen, the plants absorbing the carbon to build up woody fibre, and restoring the oxygen to the atmosphere.

Light appears to exert little or no effect on the normal process of respiration of plants, unless relatively very intense, when it may possibly promote it; but in so far as light influences oxidation processes, other than respiration, the action increases with the intensity of the light.[1] Pringsheim not only showed that the action is really due to light and not to heat-rays, but that the more refrangible rays (blue, etc.) are the most active. The activity of assimilation increases nearly in proportion to the intensity of solar light. The absence of light arrests the process of assimilation, and produces the condition known as "etiolation." The whole plant becomes colourless, due to the absence of green chlorophyll; it is curiously translucent, due to the thinness of the cell-walls, and the absence of woody fibre from the arrest of carbon-assimilation; there is a watery appearance caused by the continuance of metabolism producing elongated turgid cells, and the plant grows to death without any addition to the organic compounds it started with. Pringsheim rapidly destroyed the chlorophyll, or green colouring matter, and the vitality of plant cells by concentrating sunlight upon them and intercepting the heat-rays, and he found that this excessive effect of the refrangible rays increased oxidation and disorganised the protoplasm.

The lower cryptogamic plants, notably fungi, growing in the shade, have no chlorophyll, and light is not necessary for their growth; the more lowly organised the more inimical to them the effect of light appears to be.

The action of light on micro-organisms has been carefully studied by Dr. Arthur Downes.[2] He concluded "that the

[1] Marshall Ward, Croonian Lecture, 1890.
[2] *Proc. Roy. Soc.*, vol. xl.

solar rays are very hostile to these lowly forms of life; so much so that under favourable conditions bright sunlight, sufficiently prolonged, would altogether prevent their appearance in fluids, which, under similar conditions of temperature and the like, but screened from light, swarmed in a very few days with countless saprophytes." He found that the refrangible, actinic, or cooler rays (blue, etc.) were the most active, that the action of light was to produce oxidation, and observed the effect in the simpler as well as more complex organic substances, oxalic acid, diastase, and on micro-organisms. Gladstone and Tribe found light detrimental to the development of fungoid growths in solutions of cane-sugar exposed to atmospheric air; Tyndall, on exposing flasks of animal and vegetable infusions to alpine sunshine, found that corresponding flasks, shaded from the light, became turbid in twenty-four hours, "while thrice this time left the exposed ones without sensible damage to their transparency," and he satisfied himself by control experiments that this was not due to difference of temperature.

Dr. Downes, further, found it easy to show that diffused light possesses properties differing only in degree from those demonstrated in regard to direct sunlight, and concluded that there is a general law that light causes hyper-oxidation, and without protective developments of cell-wall, or of colouring matters which filter out injurious rays, living organisms could hardly endure the solar light.

Duclaux, in his experiments on the action of light upon microbes,[1] enfeebled and destroyed spores by exposure to sunlight for five or more weeks, whilst similar spores, not so exposed, had survived for three years. The spores, or the ovoid forms of organisms, resist light, as well as other adverse influences, better than their vegetative forms.

Arloing[2] found that the spores of anthrax bacilli were really killed by sunlight, and Roux[3] corroborated the power of sunlight to kill, and that the more rapidly in the presence of air. Further, there are the researches of Uffelmann and

[1] *Annales de l'Institut Pasteur*, 1887.
[2] *Comptes-rendus de l'Académie des sciences*, 1885.
[3] *Annales de l'Institut Pasteur*, 1887.

Gaillard upon other bacilli, and Raum has shown[1] that light has a distinctly injurious effect upon the growth of micro-organisms in connection with disease, and is therefore conducive to the health of higher organisms.

Dr. Janowski[2] has also by experiments proved that it is not the influence of oxidation of the food material by light that causes the death of the typhoid microbe, but that this is due to the direct action of the chemical rays of light upon the protoplasm of the organism, which renders it incapable of further development. Diffuse light is not so active as direct sunlight, the latter killing typhoid bacilli in from four to seven hours. He came to the conclusion that the hurtful action of both diffuse and direct sunlight is due to the chemical and to the heat - rays of the spectrum, and he has reiterated Duclaux's opinion that in our struggles with pathogenic bacteria sunlight and fresh air, in the hands of the hygienist, are most powerful and deadly weapons with which to combat their activity. Roux and Yersin, in experimenting with the bacilli of diphtheria, have found that light and air exert a powerful modifying influence upon them.

Dr. Arthur Ransome, in December 1890, communicated to the Royal Society some experiments made upon the tubercle bacillus. He found that the mere exposure to light does not destroy the virus if insanitary conditions prevail at the same time, but that light, combined with fresh air and dry sandy soil, has a distinct influence in arresting the virulence, and that darkness somewhat interferes with this disinfectant action.

Koch said, at the International Medical Congress in Berlin, that as to direct sunlight, it has been well known for some years that it kills bacteria with tolerable quickness. This can be affirmed as regards tubercle bacilli, which were killed in from a few minutes to some hours, according to the thickness of the layer in which they were exposed to the sunlight. What seems, however, to be particularly noteworthy, is that even ordinary daylight, if it last long enough, produces the same effect; cultures of tubercle bacilli die in five to seven days when exposed at the window.

[1] *Zeitschrift für Hygiene*, bd. vi.
[2] *Centralbl. f. Bakt. u. Parasit.*, 1890.

At the beginning of this century Edwards studied the effect of light upon the development of animals.[1] He exposed a portion of the spawn of frogs in water to light in a transparent vessel, and in a vessel rendered dark by protection from light he exposed another portion; they were both subject to the same temperature. Of those in the dark none did well, but those in the light developed. He made further experiments upon tadpoles, and found that the metamorphosis into frogs took place earlier and more completely in those exposed to light than in those from which light was withheld, and he concluded that solar light favoured the development of form, but that darkness was inimical to differential development, although not so much to increase of size. Further, that the greatest effects were produced upon the youngest animals.

That the number of the varieties of organised species growing in water containing animal matter increases with the intensity of light has been shown by M. Ch. Morren. M. Béclard observed that a fly's eggs submitted to the influence of violet and blue light developed more quickly, and increased to greater size, than those submitted to red, yellow, white, or green. The influence of light ought to be expected to exert its action upon pulmonary and cutaneous respiration. Moleschott observed in frogs that the exhalation of carbonic acid was greater in light than in darkness, and increased with the intensity of light. Béclard confirmed this, and also showed that in darkness the frog only loses by evaporation one-half the quantity of water that it loses in the light. The blind *Proteus* inhabiting the subterranean waters of the lakes of Carniola remains in an immature form of development, due, amongst other causes, to the absence of light, and Lionel Beale caused the external gills of this animal to contract by simply flashing light upon them.

Light is an essential element for organic development, and without it the higher plants and animals "etiolate." It is most essential during the developmental period; growth may continue in its absence, but elaboration is delayed. It is not absolutely necessary for animal exist-

[1] *L'influence des agens physiques sur la vie*, par W. F. Edwards, M.D., 1824.

ence, many animals being fitted for nocturnal habits, but it is necessary for the full development of healthy existence in man. Man is diurnal in habit, and correspondingly sensitive to light.

The powerful action of light upon development must constitute an important factor in the growth of the young and the future of the race. This influence partly explains the early vital energy and more rapid bodily development in southern climes. The ill effects produced by the sun in such latitudes are due to excessive heat rather than to light. In the same way the ill effects of the arctic climate are due to cold, for the light is often so intense that it is necessary to protect the eyes, especially against the light reflected from snow and ice.

We must conclude that the want of sufficient light constitutes one of the external causes which produce the ill-health and disease so prevalent amongst poor children living in narrow and dark streets, and that exposure to the sun and day-light is one of the means of restoring and maintaining health. The exquisite sensibility of the eyes to light must render them specially capable of transmitting its influence throughout the system. A. W. Macfarlane (*Lancet*, April 11, 1891) calls attention to the fact that travellers in northern climes have insisted upon the depressing effects of the absence of light during the winter period upon men and the lower animals; that it has been noted that in the insane thoughts grow far more extravagant in darkness; and that Mosso demonstrated that a ray of light falling upon the eyelid of a sleeping man caused an increased blood-supply to the brain, by stimulating activity in the nervous centres; this accords with the physiological law which decrees that the blood-supply of an organ is in ratio to its activity, and it explains to a certain extent the invigorating effects of sunshine.

As we proceed up the scale from the lowest to the highest organised beings, so the nervous system increases in complexity and sensitivity. Civilisation and education render the nervous sensations more acute and vivid. The influence of the brain and nervous system upon the health of the body is recognised as a most important consideration to town-dwellers. The depression of mind and the

depravity of morals under the shroud of darkness, and the vivacity of spirit and rise of aspiration in the flood of light, stand clearly contrasted as the effects mainly of the penetration of light through the sense of vision into the most potent and vital centre of the human economy.

Common observation attributes to light an important share in certain well recognised effects: such, for example, are the pronounced colour and healthy appearance of men living in the open, fully exposed to bright light, and the pallid tint and sickly look of those living in towns, mostly restricted to diffused light, or of those deprived of sunlight, working in mines or immured in prisons. Although, doubtless, other conditions participate in these effects, conditions dependent upon the exclusion of light, principally the exclusion of fresh air and the inability to see and to rectify the absence of cleanliness, nevertheless it is probable that the direct effects of light upon the skin, the capillaries, and the blood circulating near the surface, are appreciable.

The important effect upon health of a transparent medium like glass in the construction of dwellings can only be realised when an attempt is made to imagine the condition that would prevail without it, and the conditions that actually do prevail in the absence of glass in primitive dwellings. It must be reckoned as one of the factors contributing to the diminished mortality of modern days.

Hirsch expresses the opinion that the preponderance of chlorosis and anæmia among females is due to the more prolonged confinement indoors, and quotes numerous authorities. Huss attributes the greater incidence of this sickness upon certain districts in Sweden than upon others to the altered habits of the inhabitants, the women ceasing more and more to work in the fields, and confining themselves to the house. Lund makes the same observation as to Norway. Gras attributes it to the claustral life of young girls. Rigler in Turkey, Pruner in Egypt, and the French physicians among the Moors, record its common occurrence amongst the women living indolently behind the latticed windows of closed-in houses. Savaresy speaks similarly of the West Indies, Heinemann of Mexico, and Dudgeon of China. Doubtless the absence of pure air and

muscular movement are main factors here, but diminished light must participate in depressing the vitality and producing this "etiolate" condition.

Light is stimulant, darkness sedative. It may be generally stated that, the absence of light directly causes, in the healthy, depression of mental and vital activity, leading to a general debilitated condition, and, in the convalescent, delays recovery, bodily and mental. The value of daylight and sunlight in wards for the mentally and bodily afflicted is universally recognised, and it has even been said that the patients on the brighter side of a ward tend to recover more quickly than those on the darker.

In 1866 Sir David Brewster directed the attention of the Royal Society of Edinburgh to the influence of sunlight upon cholera, and showed that the mortality on the shaded side of narrow streets was higher than on the sunny side. Miss Florence Nightingale, in *Notes on Nursing*, considered the influence of light invaluable, and directed attention to the invariable fact that invalids turn themselves in bed towards the light.

Deficient light is generally accompanied by deficient space, and also by air deficient in quantity or quality. Every access of daylight is a possible source of air, hence adequate window-space to rooms, and ample front and rear space to houses are doubly desirable. Direct sunlight, and in a modified degree diffuse light, also warms and dries, setting up air currents, driving stagnant air from soil and surfaces, dissipating humidity, resolving unstable compounds, and encouraging cleanliness by disclosing to the eyes that which furnishes a nidus for the growth and multiplication of micro-organisms inimical to health.

There is nothing to show that artificial light *per se* is directly injurious to man. The injurious effects of artificial light, whether produced by electricity, gas, oil (mineral or vegetable), or by sperm, wax, or tallow, take place through fouling the air, and are remediable by proper ventilation. It can be readily understood that, as stated, wherever the incandescent electric light has displaced other forms of artificial light there has been less ill-health, from the fact that, whereas other forms of light are naked, the electric incandescent light is hermetically enclosed, and produces

little or no effect upon the air. Electric light is regarded as more irritating to the eyes than other forms of light, but this may be completely controlled by means of opaque and coloured glass. As deficient daylight is accompanied generally by deficient air, the addition of the products of combustion of artificial light (other than electric) renders freer communication with the outer air the more necessary.

In 1880 Sir W. Siemens communicated to the Royal Society a paper on "The influence of electric light upon vegetation, etc.," in which he arrived at the conclusion that electric light was capable of producing upon plants effects comparable to those of solar radiation; that chlorophyll was produced by it, and that bloom and fruit rich in colour and aroma could be developed by its aid. Contrary to Darwin's opinion, his experiments also went to prove that, although probably most plants require annual or winter rest, they do not as a rule require diurnal rest, or a period of rest during the twenty-four hours of the day, but make increased and vigorous progress if subjected (in winter time) to solar light during the day, and to electric light during the night. In a later communication in 1881 on "Some applications of electric energy to horticultural and agricultural purposes," he recorded the relative effects of the arc light when protected by a clear glass lantern and when left naked. "The plants in the house with the naked electric light soon manifested a withered appearance." On placing a sheet of clear glass so as to intercept the rays of the electric light from a portion only of a plant, in the course of a single night the line of demarcation was shown upon the leaves. That portion under the direct influence of the naked light was shrivelled, whereas that portion under cover of the clear glass continued to show a healthy appearance. Sir G. G. Stokes showed, in 1853, that the electric arc is particularly rich in highly refrangible invisible rays, and that these are largely absorbed in their passage through clear glass; it therefore appears reasonable to suppose that it is those highly refrangible rays beyond the visible spectrum that work destruction on vegetable cells; thus contrasting with the luminous rays of less refrangibility, which, on the contrary, stimulate their organic action.

. In the Savings Bank Department of the General Post Office, according to Mr. W. H. Preece, F.R.S., the cost of the electric light is actually paid for by the increased service of the staff; it has diminished the sick absence by two days per head per annum. This would mean, that the effect of fouling the air of interiors by gas is to increase sickness two days per head per annum more than prevails with the use of electric light.

Heat is absorbed by all substances through which it passes, or upon which it impinges, but in varying degrees. No substance is perfectly diathermic. Roughly speaking, gases are most diathermic, liquids less so, and solids least.

Bodies give out heat by convection, conduction, and radiation. Convection takes place more rapidly in gases, less so in liquids. Inversely, solids are the best conductors, liquids not so good, whilst gases are the worst conductors. These physical properties are of great interest to the hygienist, since the action of temperature, and the resultant reaction, is the main factor of climate. The sun's rays, radiating through space, impinge upon air, water, and soil, and the relative powers of radiation, convection, and conduction produce the leading phenomena of meteorology. The temperature of the soil is more localised than that of water, and that of water than that of the air; with increased mobility of the medium there is increased distribution and equability, the air being the principal distributor.

The effect of the sun upon the soil is to heat and to dry it, and the air passing over is also heated and dried, causing hot, dry winds—for instance, the sirocco of the desert. The sun falling upon water evaporates it, and the passing air becomes cooled and saturated with vapour, causing cool, moist winds—for instance, the breezes of the ocean. The heating of the air in one spot, and the cooling in another, cause those inequalities of pressure, measured by the barometer, which produce winds in the adjustment of equilibrium, by the displacement of air from a high pressure to a low pressure area. With the variation of temperature, the capacity of the air for holding water vapour varies; the withdrawal of heat causes condensation, producing

the clouds carried by the higher air currents, and the clouds descend as rain, hail, or snow.

Water has the greatest specific heat of all substances known. If the relative heat of water were low, it would become very hot in summer and very cold in winter; whereas we know that the temperature of bodies of water rises only slightly in summer, and falls but gradually in winter, being, as compared with the land, colder in summer and warmer in winter. This is the cause of the seasonal winds called monsoons, and the diurnal wind-currents known as land- and sea-breezes, the specific heat of soil and rocks being about one-fourth that of water. Hence climates are insular or inland according to the proximity of water. An inland climate is characterised by extremes of temperature and greater dryness, and an insular climate by equability and greater humidity.

The temperature of climate is also influenced by latitude and altitude, as well as by water. Latitude determines the angle of incidence of the sun's rays; they are vertical at the equator, and their heating power is reduced as the angle of incidence diminishes towards the poles. Altitude lowers the temperature by rarefaction of the air. For every 300 feet we are removed from the surface at sea-level there is a fall of about 1° F. of temperature. Mountains cause the wind to deposit its moisture, removing the vapour screen, and, allowing solar and terrestrial radiation fuller play, produce extreme temperatures. Radiation is most intense where there is least vegetation. Forests impart somewhat of the insular character to climate by intercepting solar and terrestrial radiation, and increasing the humidity. The destruction of forests is known to change entirely the climate of a country.

The humidity of the air is dependent upon temperature and the proximity of water. Water vapour being a better conductor than air, the effects of temperature are intensified by humidity. Similarly, increased rapidity in the movement of the air intensifies the effects of temperature upon the body, the effect of a high wind with a falling temperature being especially noticeable.

The mean temperatures of the surface of the earth do not follow the lines of latitude, but vary under physical

influences. These variations are depicted by isothermal lines encircling the globe latitudinally in a curvilinear manner. These isothermal lines approximately mark the limits of five varieties of climate:—Under 20° F. polar, 20° to 40° F. cold, 40° to 60° F. temperate, 60° to 80° F. hot, over 80° F. torrid.

The hottest space upon the earth within which temperatures have been recorded is situated upon the south-west coast of Persia, upon the border of the Persian Gulf. In 1890, for forty days and nights, during July and August, the thermometer never fell below 100° F., and frequently reached 128° F. The coldest space lies over the extreme north-eastern part of Siberia, where an average temperature of $-40°$ F. prevails.

The isothermal lines of mean temperature only very roughly limit the boundaries of the various species of animals, and do not form an exact guide to the fauna of a locality, partly because they are the result of extremely dissimilar factors, and do not record the range and duration of varying temperatures, and partly because animals are locomotive; they therefore do not supply a graduated measure of the effects of temperature upon animal life. Vegetable life being more stationary, the boundaries of vegetable species are more definite, but altitude and humidity limit them as well as thermal conditions.

Range of temperature is of more importance than the mean, marking as it does the extreme maximum and minimum. An equable temperature depends less on latitude than on configuration of land, proximity of sea, and direction of winds and currents. The most equable temperature is enjoyed by parasites living in the bodies of warm-blooded animals, and shielded from climatic influences.

The temperature of plants depends upon the temperature of the soil as well as the temperature of the air, the density of the bark, the protection of the foliage, and the evaporation from its surface. The temperature required by plants varies according to genera and varieties, and plants distribute themselves not only with regard to latitude, but also to altitude, so that the sum of the effects of a given altitude and a given latitude is a guide to the orders, genera, and varieties that may be expected.

The freezing-point has a very distinct influence upon vegetable life. In temperate climes the periodical revival of vegetable life takes place when the temperature ceases to fall below freezing-point, a fact within common observation, and the polar region, at the point where the mean temperature falls below 32° F., harbours only a few diminutive species, and no trees, bushes, or food plants.

With a rising temperature the growth and luxuriance of vegetation increases rapidly, but when the temperature rises above 35° C. or 100° F. plants can only survive by increased power of circulation and evaporation.

In the Croonian lecture of 1890, upon "The relations between host and parasite in certain diseases of plants," Professor Marshall Ward, speaking of the effects of heat upon plants, observed that "at temperatures near 0° to 5° C. the respiration is very slow; as the temperature rises the respiratory activity increases, at first slowly, and gradually more and more rapidly, till at 35° to 45° C. it is at its *maximum* intensity; beyond that it rapidly declines, and ceases with the death of the protoplasm at about 50° C." This ensues from damage to the structure of the living substance, owing to the excessive disturbances brought about in its metabolism. Metabolism and growth are affected concurrently, except that growth does not commence at such a low temperature, and declines at a less high temperature.

The combined effect of low temperature, feeble light, and an atmosphere saturated with moisture upon a plant, is that the cell-walls are thinner and more watery, the cell-sap abounds in glucose, acids, and soluble nitrogenous matters, and the protoplasm lining each cell is less capable of destroying substances that can injure it—its respiratory processes being enfeebled—and experiments have proved that such plants not only offer less resistance to the hyphæ of a parasite, but the very conditions which cause the plant to abound in materials suitable to the fungus also suit the lower type of growth itself.

The limit of temperature below which the growth and multiplication of microbes ceases and cold-rigidity sets in is approximately 5° C., although it is possible to subject many to much lower temperatures of short duration without

killing them, *e.g.*, anthrax to – 110° C. and cholera to – 10° C. Similarly a high temperature, when it reaches about 45° C., generally arrests development, producing a condition of heat-rigidity. Temperatures of 56° to 60° C., after sufficiently long exposure, permanently destroy the growing forms of bacteria. Spores are less amenable to the influence of temperature than the growing forms. Between the maximum and minimum above mentioned is a wide range, within which the optimum temperature of each micro-organism is to be found. The optimum temperature of pathological bacteria is about that of the body; generally speaking, the saprophytic have an optimum about 20° C., or 70° F. But each form has its own optimum.

Dr. Janowski[1] records a number of experiments upon the typhoid bacillus made in a double-walled vessel, containing water in the inner and hot air in the outer chamber, the whole surrounded by felt, by which means the radiation and conduction were so equalised that the same temperature was maintained uniformly. He subjected the bacillus, growing in tubes containing gelatine and placed in the water, to various temperatures for five or ten minutes, and then made plate cultivations of them. As regards high temperatures, when exposed for ten minutes to 55° C. (131° F.), the cultivations were sterile, the bacilli being killed, but the same temperature maintained for five minutes was insufficient to kill. He concluded, in accord with Sternberg, that a temperature of 56° C. was fatal to the development of the bacilli. As regards low temperatures, after subjecting the bacilli, in broth and on threads, to various degrees of cold, he concluded that extreme cold, when continued for some time or frequently repeated, injures the vitality of the bacillus,—14° C. completely destroying it in a fluid medium, but being of less effect in a dry.

The Klebs-Löffler bacillus of diphtheria is killed at a temperature of 60° C. in a moist atmosphere, but in a dry will survive a temperature of 98° C. The tubercle bacillus only grows at a temperature varying between 30° and 41° C.,—best at 37° C., the temperature of the blood. The lowest limit of growth for the spirillum of Asiatic cholera is from

[1] *Centralbl. f. Bakt. u. Parasit.*, 1890.

15° to 16° C., for the bacilli of glanders about 22° C. The highest limit for the lactic acid bacillus is just over 45° C., for the Bacterium termo from 40° to 43° C., and for the Bacillus subtilis from 50° to 55° C. Of the micro-organisms gaining access to a given nidus the temperature must mainly determine which species will develop and prevail.

High artificial temperature is a powerful agent for the actual destruction of micro-organisms, whereas low temperature reduces them only to a latent vitality. The effects of high temperature depend upon the degree, duration, and humidity of the heat, and the resisting power of the organism. The drier the heat the longer is the time required to kill, and the longer the duration of exposure to the heat the lower the temperature necessary. Some forms require greater heat than others; the spore-bearing forms require the highest temperature, but if the heat be applied intermittently and repeatedly, so that the spores may develop into bacilli, a relatively low temperature will suffice to kill.

Moist heat from 48° to 60° C. generally suffices to kill within a short time most organisms not in the spore stage; if the heat be dry, either the temperature must be raised or be continued for a longer period. Dry heat of 140° C. will only kill spores after an application of several hours, but steam at or above 100° C. will kill within an hour the most resistant, and many within a quarter of an hour.

Although parasites inside warm-blooded animals are generally subject to the most equable temperature, the *distomum* of the bat undergoes no further development during the winter sleep of its host (Van Beneden); and the entozoa of cold-blooded animals, when they have not arrived at maturity, stop their metamorphosis during the winter, and produce no eggs, or only very few (Leuckart).

All animals are more or less dependent upon warmth, the higher animals more than the lower, but especially the warm-blooded animals. Animals living in the same climate are affected in a different manner by the variations of temperature. Every animal possesses an optimum temperature, and a varying power of endurance of the divergences to extremes. Möbius classifies animals capable of sustaining greater range as *eurythermal*, and those supporting only a

small range of temperature as *stenothermal*. The optimum may be extremely different in different animals; some animals may revive even after being hard frozen, particularly some cold-blooded animals. The temperature of cold-blooded animals varies with the medium in which they are placed; reptiles in a medium of 75° F. average a temperature of 82° F. Of warm-blooded animals the warmest are birds, averaging 107° F.; mammals average 101° F.; and man's constant temperature is 98.8° F. Adult frogs may be frozen and revive; the eggs of salmon are transported across the Equator in ice, and develop when laid down; and the eggs and germs of many of the lowest species resist extreme degrees of cold. But although animals may passively resist extreme cold, active animal life can only proceed as the temperature nears the optimum; as the temperature rises above this, the activity is again reduced, inducing sleep, passing into a condition of heat-coma and death. Frogs die in water at a temperature of 104° F.; at 120° F. the muscles of mammals and birds assume a condition of heat-rigor, and coagulation of the muscle plasma of the heart takes place in man at 115° F. Few species of animals can long survive a transfer from a tropical to an arctic region, or the reverse. Death from extreme cold is preceded by a condition of diminished vital energy, followed by suspended animation, from which an animal may revive after considerable duration; but death from extreme heat is preceded by increased functional energy, increasing metabolism, culminating in protoplasmic coagulation and heat-rigor, from which there is no revival.

The effect of warmth is thus an important factor of development. The hen's egg requires a constant temperature of 104° F.; if lower, the development is retarded, and ceases at the ordinary temperature of the house, 60° F. Many eggs will survive much lower temperatures, but will not develop except under the influence of a moderately high temperature of sufficient constancy.

An extreme climate gives rise to sharply defined periodicity, growth and development being checked in winter and stimulated in summer. An equable climate, on the other hand, especially as the temperature approaches uniformity throughout the year, obliterates this periodicity,

growth and development proceeding continuously. Hence an equable climate is most favourable, and permits of acclimatisation more readily than an extreme one. Mr. Charles Buxton, M.P., maintained in England, in the open, a number of species of cockatoos and tropical parrots, which survived the winters, and even voluntarily cross-bred, producing hybrids.[1]

The extremes of temperature compatible with human life are difficult to fix, and depend greatly upon duration and manner of application. A temperature of 212° F. on the one hand, and of 32° F. on the other, will rapidly kill if applied to the exposed surface by means of water; but applied through the medium of air, the effect is less injurious, and can be endured for a considerable time. Protection from the effects of air at low temperature is obtained by clothing, and at high temperature by evaporation from the surface, provided the atmosphere be dry.

Indolence becomes a necessity during the hot seasons in the tropics; on the other hand, the winter in countries without the tropics is conducive to activity, and, although the fall of temperature may not be directly beneficial, it is economically and indirectly so by imparting a stimulus to supplying the means of maintaining healthy existence.

The temperatures of climate have little influence on the normal temperature of the human body. Copious perspiration prevents the temperature of the body being raised by external heat, as increase in the amount of fat consumed as food prevents the temperature being lowered by external cold. Man well fed, clothed, and sheltered, can withstand a temperature of − 70° F. in still air, but a much less degree of cold than this suffices to produce frost-bite of the extremities in moving air. The direct local effects of temperature are sunburn and frostbite. The direct general effects are heat-exhaustion supervening slowly, and heat-stroke, a more rapid result, from increased coagulability, or from coagulation of the blood and tissue elements producing heat-rigidity, especially of the heart muscle. Similarly, from the effects of cold, a cold-torpidity supervenes slowly, and more or less sudden stoppage of the

[1] Semper, *Animal Life*.

action of the heart may result from the congestion of the circulation, especially the pulmonary.

The application of cold to the skin withdraws heat firstly from the more superficial, and later from the deeper layer, but this loss is rapidly restored. Cold air and cold water are recognised as tonic and bracing, the reason being that as more oxygen is absorbed by the lungs the effete products in the tissues are more freely oxidised, causing increased combustion to compensate for loss of heat, and the more complete and rapid destruction and construction produce an invigorating effect.

The bodily heat of a naked man cannot be long maintained in a temperature below 27° C. or 80° F., and overheating will supervene at a temperature in dry air in excess of 50° C. or 122° F., or less if the air be moist.[1] Broadly speaking, the bodily temperature of man, which is constant at 98.8° F., cannot, under primitive conditions, for any great length of time withstand an external temperature 20° lower or higher than the constant. Clothing materially alters the conditions, so that a much lower temperature may be borne, and with shelter and artificial heat in addition, man is enabled to survive residence in the lowest natural temperatures, such as −40° F. in North-Eastern Siberia, and lower still in the polar region.

Upon the cutaneous system the effect of external heat is to render the skin more or less turgescent, to increase the flow of blood through the cutaneous vessels, and excite the excretion of sweat. In the cold the skin becomes pale, the cutaneous vessels contract, and less blood flows to the surface. Thus the skin acts as a regulator of temperature losing heat in the former case and retaining it in the latter.

The effects upon the circulatory system are mainly due to the dilatation and contraction of the capillaries of the surface under the influence of heat and cold. Heat dilates the capillaries, reducing the resistance necessary to be overcome by the heart, which therefore beats more quickly, and with the reduced resistance the arteries exhibit diminished resiliency. Cold (or alternations of heat and cold) causes the capillaries to contract, throwing increased propulsive

[1] Senator, quoted by Cohnheim.

exertion upon the heart, which beats slower, the calibre of the arteries yielding to the pressure from the capillaries on the one hand and the heart on the other, and then by their resiliency slowly contracting again. Under the influence of cold the tendency is for the blood pressure to be higher and the circulation slower, and under that of heat the circulation quickens and the pressure falls.

The effects upon the respiratory system are to modify the quantity and quality of the gases and vapours expired. The amount of carbonic acid exhaled, and of oxygen absorbed, is greatly increased by external cold and diminished by heat, due to variation in the metabolism of the tissues.

It is a familiar fact that in dry air a much higher temperature can be borne than in moist air. Contrast the hot, dry air bath with the vapour bath. The dryness of the air facilitates the rapid evaporation of the perspiration, the secretion of which by the cutaneous glands is promoted by heat applied to the surface, and the large amount of heat which is consumed in this change is for the most part withdrawn from the body, the temperature of which is thus kept down. On the other hand, an atmosphere saturated with moisture does not permit of such free transpiration.

In estimating the effects of temperature upon the health of the community it cannot be inferred that the season of highest mortality is also that of the greatest sickness. Frequently they coincide, but it may happen that a season of great sickness may yield a comparatively low rate of mortality, or a mortality not at all commensurate with the morbidity. Unfortunately it is difficult to obtain reliable data of morbidity, but mortality returns are more accessible and more accurate.

Dr. Guy carefully compared the relation of temperature to mortality,[1] and came to the following conclusions :—

(1.) That the division of the year into three sections consisting respectively of four months each—the cold, the temperate, and the hot—is that best fitted to reveal the true relation of temperature to mortality.

(2.) That if, in a table which records the mortality of the several months of the year, we distinguish the maxima, minima, and average mortalities by appropriate marks or

[1] *Journ. Stat. Soc.*, 1881.

signs, we at once discover a certain relation between temperature and mortality.

(3.) That if we proceed to arrange the months of the table into three groups of four each, this relation between temperature and mortality shows itself still more distinctly. The number of deaths varies inversely as the temperature.

(4.) If we adopt the same procedure with a table which comprises the ages at death (making such corrections as may be needed to equalise the three sections of the year), the dependence of mortality on temperature is made apparent for every age and period of life.

(5.) That the inverse relation which exists between temperature and mortality is the ultimate result of a conflict of forces, in which the deaths from diseases of the lungs and from old age assert their predominance over deaths from such diseases as those of the liver and alimentary canal, that vary directly as the temperature, as well as over a mixed group of diseases, which, as causes of death, follow neither of these rules.

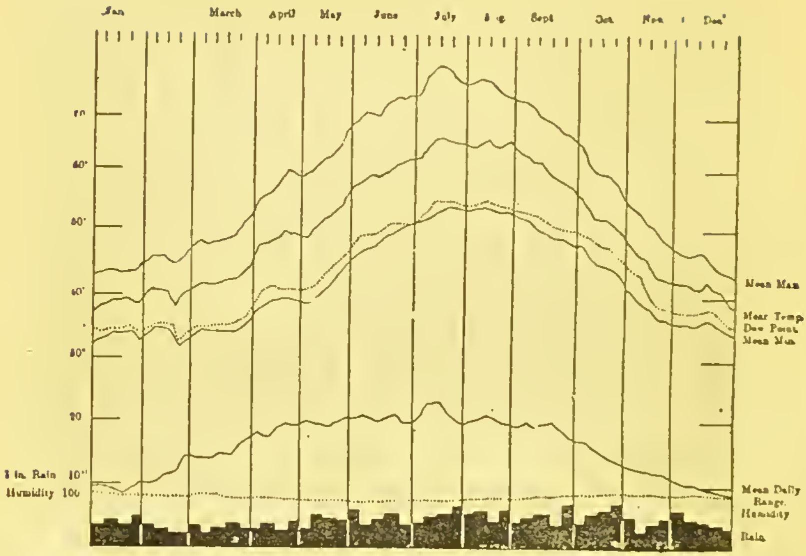
(6.) That epidemics of plague and other diseases in remote times, and of cholera and choleraic diarrhœa in our own days, have occasioned such an excess of deaths in the warmer months as to mask the true order of mortality in these temperate regions.

Buchan and Mitchell have carefully calculated, and graphically recorded, the influence of weather on mortality from different diseases and at different ages during thirty years in London.[1] They regard climate as mainly determined by temperature and moisture, and divide the year into six periods, as follows:—

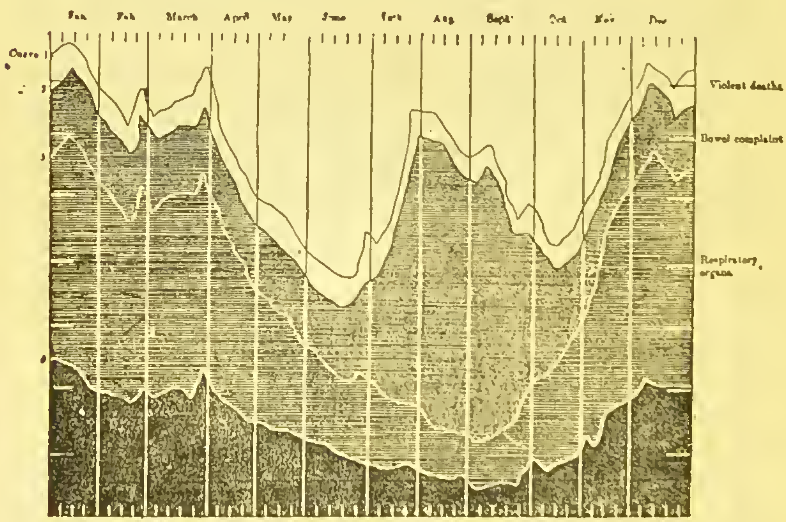
Periods.	Extending from	Climatic Characteristics.
First . .	4th week of Oct. to 3rd week of Dec.	Dampness and cold
Second .	4th ,, Dec. to 3rd ,, Feb.	Cold
Third .	4th ,, Feb. to 2nd ,, April	Dryness and cold
Fourth .	3rd ,, April to 4th ,, June	Dryness and warmth
Fifth .	5th ,, June to 4th ,, Aug.	Heat
Sixth .	1st ,, Sept. to 3rd ,, Oct.	Dampness and warmth

The cold period is characterised by a death-rate larger than at any other season. It is also the time when

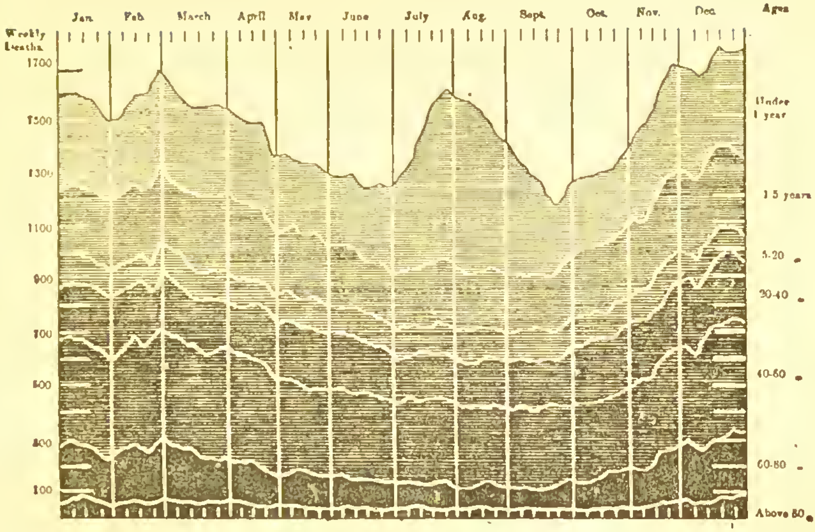
[1] *Journ. Scot. Met. Soc.*, 1875.



Meteorology of London, 1845-1874. (After Buchan and Mitchell.)



Mortality from several causes. London. (After Buchan and Mitchell.)



Mortality at different ages. London. (After Buchan and Mitchell.)

the largest number of diseases either show an excessive mortality or reach the maximum for the year. The diseases which indicate a mortality much above the average are chiefly those connected with the air passages, the nervous system, and the circulation, the diseases of the respiratory organs showing the largest excess.

The period of heat possesses a prominent feature in the high death-rate from diseases of the abdominal organs, which reach their annual maximum at this time.

The variation of the influence of temperature at different ages is such that by eliminating the deaths under one year of age the whole of the summer excess in the death-rate disappears. Heat is peculiarly destructive to infant life. Cold exerts an inimical influence upon life at all ages; but at the weakly ages, whether infantile or senile, the influence is more fatal, but on account of the extra care and warmth bestowed on infancy the effect is not so patent as in senility, and cold therefore appears as the great destroyer of life amongst the aged.

The temperature under the influence of which the lowest mortality takes place must vary with every race and climate.

Scoresby Jackson[1] concluded that in Scotland, for every diminution of mean temperature below 50° F. there is a corresponding increase of mortality, but that from mean temperatures above 50° F. a diminution is favourable to vitality, at least if the temperature had been for any length of time above 50° F. In other words, mean temperature and mortality from all causes have an inverse relationship below 50° F., a direct relationship above 50° F.

Air being a bad conductor of heat, water a better, and vapour better still, air laden with moisture consequently conveys extremes of temperature more readily than when dry, and, from the effect of preventing perspiration when hot and moist, has an additional effect in raising the temperature of the body, whereas in cold weather moisture, although conducting the cold better to the surface, prevents to a small extent the loss of heat from the body.

Extremes of temperature are always fatal, but especially if of long duration. There is a direct relationship to mortality from winds blowing from north and east, and an inverse relationship from winds blowing from south and west. The popular saying that a green yule makes a full churchyard, far from being correct, is opposed to statistical proof. The young, the strong, and the healthy are stimulated by the cold. But to the infantile, the aged, the weakly, and the poor, lacking clothing, shelter, food, and warmth, cold is fatal.

So far as climate is concerned no single meteorological influence appears to equal the effect of temperature upon health. The European under a tropical climate suffers from anæmia, diseases of the digestive system, especially of the liver, from malaria, typhoid and yellow fevers, and dysentery. Change of climate may be beneficial, but a climate favourable to one organ or function is often prejudicial to another. Thus, a climate benefiting pulmonary disease may promote hepatic disease, or whilst warding off rheumatism may communicate malaria or yellow fever. A warm, dry climate may allow of increased out-door life, but may also be as beneficial to the lower forms of life as to the higher, and give rise to increased risk from parasitic disease. In India, during the hot season, although small-pox is then most rife, vaccination cannot be performed on account of

[1] "Effects of Weather on Mortality," *Trans. Roy. Soc. Edin.*, 1864.

the development of the vesicles being accelerated and accentuated.

Great summer heat is often accompanied by fatal epidemics, and, if not the direct, may be a predisposing, cause of them. A hot climate produces two main effects, it promotes the growth and multiplication of micro-organisms and the exhalation of carbonic acid, but the absorption of oxygen being diminished, it causes effete products to be less perfectly oxidised and to accumulate in the blood, producing congestive effects upon the liver and digestive organs, and prepares a suitable nidus for the location of organisms.

The inhabitants of arctic regions are liable to affections of the respiratory organs, and especially to the *grippe*, or *arctic influenza*. A torrid climate, the other extreme, develops constitutional anæmia and favours the formation of miasms.

Race accentuates the effects of temperature or of climate. It is impossible to acclimatise negroes in regions situated far northward of the country of their origin. They fall victims to thoracic diseases, affections of the pulmonary organs, especially phthisis. The white races, although widely extended, fail to multiply and prosper in torrid climates, especially in the plains and valleys, and they become victims of miasmatic diseases.

Diseases dependent upon climate are of two distinct kinds—(1) Those caused by telluric emanations and characterised by the different forms of malarious diseases; and (2) those caused by atmospheric vicissitudes, the variations of temperature and humidity. The former diminish from the equator to the pole, the latter increase. The former include mainly abdominal and infectious diseases, the second those of respiration and movement. In a temperate climate the variety and number of diseases are more numerous than in an equatorial, but generally less fatal.

Locally, foliage and overhanging rock afford natural protection against the direct rays of the sun, and artificial protection is obtained by portable shades, head-gear, and clothing, or by fixed canopies and roofs; and just as some conformations of surface due to vegetation or soil naturally ward off cold and hot winds, so for the same purpose artificial screens of temporary or permanent materials are utilised.

The two combined constitute the roof and walls of the dwelling, by which means an enclosed space is obtained, the contained air of which, under a low natural temperature, may be warmed to a degree compatible with existence, constituting an artificial climate.

Senator has shown, as already mentioned, that in an external temperature lower than about 27° C., a naked man cannot maintain his bodily heat. Without clothes even very energetic muscular movement and a large consumption of heat-producing foods could not maintain the bodily heat in the average temperature of dwelling rooms. Hence the increasing importance of the influence of clothing, and of dwelling, as we recede from the tropics towards the poles. An infant requires to be more carefully protected from cold by clothing and dwelling than an adult, because, in proportion to bulk for the production of heat, it possesses greater surface for the loss of heat than an adult. A cube whose sides are 1 inch square contains 1 cubic inch, but a cube whose sides are 2 inches square contains 8 cubic inches; the former has 6 inches of surface to 1 cubic inch of bulk, whereas the latter has only 12 inches of surface to 8 cubic inches of bulk; the proportion in the former is 6 to 1, whereas in the latter it is only $1\frac{1}{2}$ to 1.

As in the case of artificial light, artificial warmth, except in the case of destructive heat, produces its ill results upon health mainly by indirect effect in fouling the air.

Electric light of the same intensity as gas produces only about one-twentieth of the number of caloric units. Comparing the amount of heat emitted from various luminous sources per hour, the following are the approximate results: —Electricity, 46 caloric units (man = 92 caloric units); mineral oil, 7 men; gas, 8 men; stearine, 17 men (Pettenkofer). As to relative cost, an important practical point, taking mineral oil as the unit, gas is twice, electricity thrice, vegetable oil seven, and stearine twenty-seven times the cost.

Heating by means of hot air and hot water pipes tends to dry the air unduly, and close stoves produce a similar effect. Open fires possess the advantage of warming by radiant heat, and of circulating the air and ventilating more freely. The disadvantages of burning coal are the dust

and smoke created, which there are great difficulties in overcoming; wood and coke are less smoky combustibles; but mineral oil and gas obviate this entirely, the latter being a perfect if an expensive calorifacient in the open grate. Thus the relative effects upon health of these several forms of heat are produced indirectly by their action upon the air.

Artificial cold finds its most useful application in the preservation of food by lowering the temperature to or below a point at which micro-organisms cease to grow and multiply, and arresting the destructive changes of decomposition.

CHAPTER III.

CHEMICAL MEDIA.

PURE air, when measured by volume, contains nearly 21 per cent. of oxygen and 79 per cent. of nitrogen, a very variable quantity of aqueous vapour, and traces of carbonic acid, ammonia, and ozone. Impure air, besides possessing less oxygen and ozone, and more carbonic acid and ammonia, than pure air, may also be found to contain many gaseous impurities as well as suspended matters, inorganic and organic, dead and living, air being rendered impure by respiration, combustion, putrefaction, and industrial processes.

The means by which the impurities discharged into the air are removed or rendered innocuous, and the uniform composition of the air is maintained, are various. By diffusion gaseous impurities are diluted, the wind blows away suspended as well as gaseous matters, the rain precipitates them to the surface, the oxygen enters into chemical combinations with them, and whilst animal-life is removing oxygen and yielding carbonic acid, plant-life is taking carbonic acid and restoring oxygen. Suspended impurities accumulate in proportion to the stagnation of the air. The effect of wind on land is to aerate the surface of the soil and perflate the interior of dwellings, and it ruffles the surface of water, preventing stagnation, aerating the superficial stratum, and inducing currents. The result of constructing dwellings in such a manner that the space about them is restricted or obstructed is to cause stagnation of the air and the accumulation of impurities, inorganic and organic, dead and living organisms.

Impurities may be discharged into the air of a locality in such quantities and of such qualities as to overtax the power of diffusion and materially pollute the common

atmosphere. Or the impurities produced may be of such a kind that, although pernicious in interiors, they may have little effect when diffused into the external air. The former can only be dealt with by suppression; the latter may be remedied by ventilation and perflation.

Oxygen is the most active principle of air, supporting combustion and life. Angus Smith found the volume of oxygen to vary from 20.999 per cent. on the sea-shore and open heath to 18.270 at the bottom of a mine. The variation under ordinary conditions may be taken as from 21.0 to 20.5 per cent. Oxygen exists also in an allotropic form as *ozone*, a condensed form of oxygen, being one-and-a-half times denser. In large quantities it is irritating to the mucous membranes, in smaller it is a powerful oxidiser, and exerts a beneficial influence upon health by its presence in the air of the open country, and of the sea. It is not generally found in the air of towns, nor in the presence of respiration, decomposition, and combustion.

Carbonic acid is always present in the air in greater or less quantities, and is derived from subterranean sources, either in the form of gas or in solution in natural waters, from the fermentative, putrefactive, and respiratory processes of vegetable and animal life, and from combustion. The amount present in pure mountain air averages 0.3 per 1000 volumes. In town-streets, Angus Smith found it to average 0.36 per 1000 in London, and 0.40 in Manchester, in proximity to its production, and in close interiors the amount may be much greater. When increased to the proportion of about 15 per 1000 it commences to produce headache and nausea, at 25 per 1000 it extinguishes light, at 50 it commences to produce symptoms of insensibility, and over this amount it is fatal. Carbonic acid is usually taken as the index of organic impurity, and 0.6 per 1000 is held to be the limit compatible with health.

Carbonic oxide is a very poisonous gas, less than one per cent. in the air proving fatal. The red blood corpuscles have a greater affinity for carbonic oxide than for oxygen or carbonic acid, and readily take it up, forming a permanent compound with the hæmoglobin, and producing death by asphyxia. Sulphuretted hydrogen, when present in enclosed spaces, appears to exercise a debilitating effect

upon the health of those continuously exposed to it, producing anæmia; in large quantities it may give rise to serious effects. Carburetted hydrogen or marsh gas, breathed in small quantities, produces little or no effect, but in large quantities may prove fatal. Ammonia compounds are derived mainly from animals and putrefaction, and are then only injurious from the impurities accompanying them. Ammoniacal vapours are liable to prove irritating to the eyes, and possibly to other mucous membranes. Sulphurous acid, hydrochloric acid, carbon bisulphide, and other gases are discharged into the air, and are more or less injurious to health and destructive to vegetation, according to the amount present.

Suspended matters are found in the air in enormous variety. Every form of matter that may be sufficiently comminuted and wafted by air currents may be present. Suspended matters of various kinds are recognised causes of disease of the respiratory organs, producing effects passing through the stages of irritation, catarrh, bronchitis, and possibly proceeding to emphysema or pneumonia. Metal miners, pottery and china workers, grinders in steel, mother-of-pearl, bone, and other hard substances, workers in textile factories, bakeries, and many other works are rendered liable to respiratory diseases. Workers in different metals and chemicals, such as lead, mercurial, and arsenical compounds, are also liable to various forms of chronic poisoning.

The suspended matters may also be organic substances, dead or living, and may consist of vegetable or animal forms, such as the pollen of grasses and flowers, which prove very irritating to some mucous membranes, and produce hay-fever and irritable catarrhs. The spores of the fungi productive of various skin diseases may be conveyed through the air. The contagia are also so conveyed, and produce disease either by inhalation, ingestion, or inoculation, but this properly belongs to the subject of micro-organisms.

The respiration of man and animals deprives the air of oxygen, and charges it with carbonic acid, watery vapour, ammonia, and organic matters. An adult man abstracts from 4 to 5 per cent. of oxygen from the air at each inspiration, and expires about the same amount of carbonic acid and watery vapour. An average adult, when not at work,

gives off about 0.6 cubic foot of carbonic acid per hour, rendering about 3000 cubic feet impure, the standard limit of impurity being 0.6 cubic foot of carbonic acid per 1000 cubic feet of air. As 1000 cubic feet of air contain 0.4 of carbonic acid, therefore the addition of 0.2 cubic foot will reach this limit, and as an adult gives off 0.6 per hour, 3000 cubic feet of fresh air per hour are required in order not to exceed it. Carbonic acid is taken as the measure of impurity because it is readily estimated, but the organic matters are immeasurably more deleterious to health. Carbonic acid does not diffuse too readily, but the organic products expired from the lungs and exhaled from the skin diffuse still less readily, remaining suspended in the air of rooms and clinging to the surfaces. It is a matter of common observation that perflation by means of an open door and window more rapidly and more perfectly purifies the air of a room in a few minutes than many hours' ventilation by the ventilators in common use. The daily perflation of dwellings is as necessary to health as the continuous ventilation, but is insufficiently insisted upon.

As 3000 cubic feet of fresh air are required per head per hour, and as a more frequent change than three times per hour cannot be generally borne in this climate, a higher velocity of the incoming air causing perceptible draughts, it is held that 1000 cubic feet of air-space per head is the desirable minimum.

Although 1000 cubic feet is theoretically assumed as the minimum standard of air-space, in practice the minimum varies widely, as the following table will show :—

	Cubic ft.	Sq. ft.
Local Government Board (Railways and Canal boats)	60	
On board merchant ships	72	12
Common lodging-houses (Metropolitan)	240	30
Poor Law—Workhouse dormitories	300	
Bye-laws, houses let in lodgings	400	
Army huts	400	
Police—Metropolis	450	50
Army—Permanent barracks	600	
Poor Law—Infirm wards	500-850	
Army—Hospital huts	600	
Prisons—Separate cells	800	
Poor Law—Sick wards	1200	
Army—Hospital buildings	1200	
General hospitals	1200	

Technically, "over-crowding" applies to crowding persons together until the amount of cubic space occupied by each is reduced below the minimum limit allowed by particular and varying regulations, more or less regardless of the means of ventilation. But overcrowding, understood as putting into a given cubic space a greater number of individuals than will permit of the maintenance of the contained air in a reasonable state of purity, depends, not only upon the size of the space, but also upon the amount and mode of ventilation. A maximum amount of space inadequately ventilated may be rather worse than a minimum space well supplied with fresh air. Under these conditions the sailor's narrow bunk on the open ocean may be rendered preferable to a fair-sized bedroom in the town.

Breathing air fouled by the products of respiration produces, according to extent and duration, increasing drowsiness, headache, and nausea, and ultimately poisoning by organic exhalations, asphyxia, and death. Habitual breathing of less foul air produces malnutrition, languor, and anæmia. It is universally recognised as the most fertile cause of phthisis or destructive lung disease. Although tuberculosis may be attributed to a specific organism, the effects of breathing air where the ventilation is bad, and the atmosphere charged with organic effluvia, must still be recognised as producing a state of health predisposing to scrofulous and tuberculous conditions, and of aggravating those conditions when present by the pernicious effects upon the respiratory organs in particular, exciting acute and chronic lung affections, bronchitis, and pneumonia.

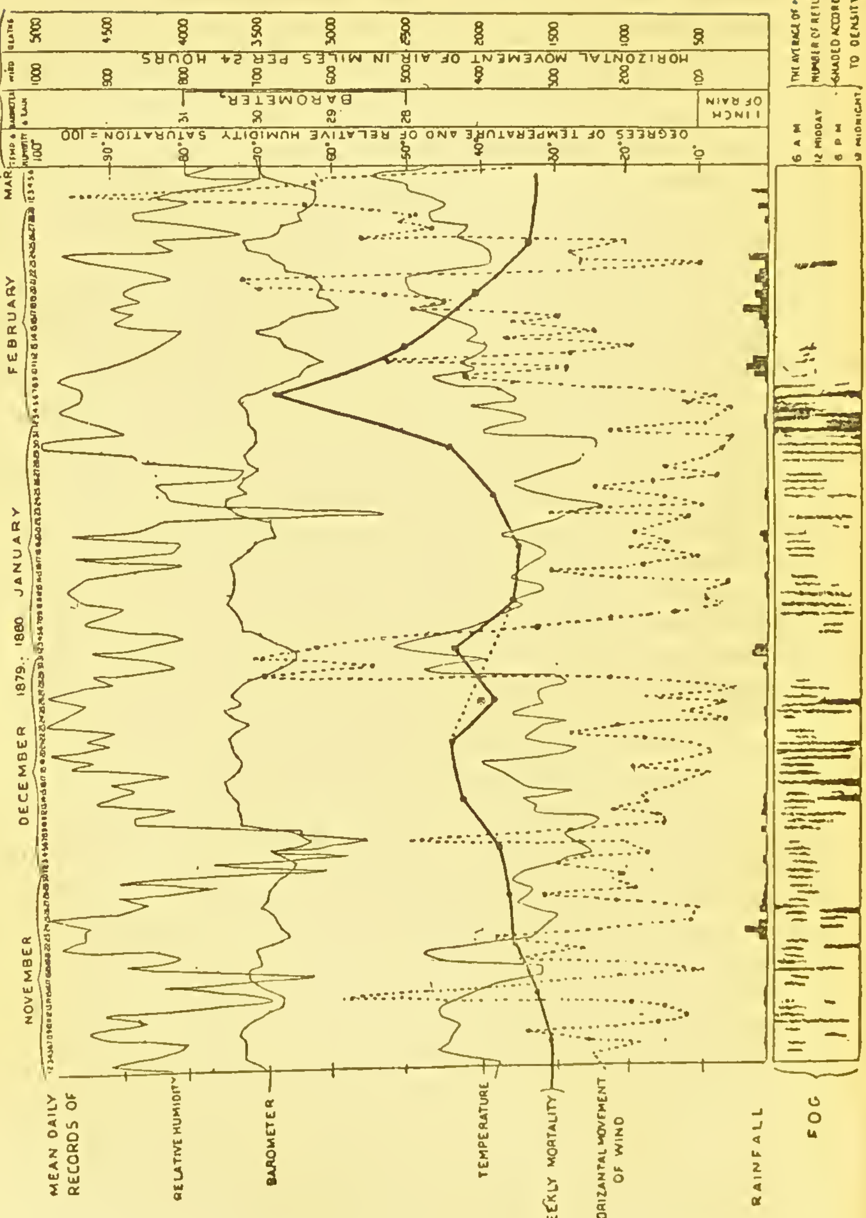
The spread of specific febrile diseases is greatly encouraged by breathing air vitiated by the organic matters given off from the lungs and the skin, both by the deteriorating effect on the general health and by the favourable medium created for the propagation and transmission of the specific contagia. This applies especially to such diseases as typhus, plague, small-pox, scarlet fever, diphtheria, measles, erysipelas, phagedæna. Hence the beneficial influence exerted by treatment of such cases in open huts or tents.

Combustion takes place under two different conditions—in heating and in lighting. In the process of heating the products are discharged into the outer air by the innumer-

able small chimneys of domestic grates, and the fewer but larger chimneys of factories and other buildings. In illumination, on the other hand, the products of combustion are mainly discharged into the interior air of buildings.

Coal used for heating purposes produces on combustion carbon or soot, carbonic acid, watery vapour, carbonic oxide, and various sulphur compounds; wood produces fewer sulphur compounds. The carbonaceous and tarry matters and the sulphur compounds diffuse less readily than the other products, remain more or less suspended in the lower air, and are only dispersable by considerable winds. It has been stated that these products exert a beneficial influence by their disinfectant action; but towns do not appear to be rendered freer thereby from infectious diseases; on the other hand, town-dwellers rather suffer from the injurious effects upon the respiratory passages, exciting laryngitis, asthma, and bronchitis. In still weather, and under the accumulation of smoke, the irritating effect is appreciable to sensitive respiratory organs. But in time of fog it is most observable, especially if the products of combustion be present in sufficient quantities to produce a suffocative sensation of dryness, even in a damp fog, from the greater accumulation of the products of combustion, especially the carbonaceous, sulphurous, and tarry compounds, beyond the amount of watery vapour present. During the prevalence of the fogs in the winter of 1879-80 the mortality of London rose as high as the death-rate that prevailed during the severest cholera period. The accompanying chart shows the various meteorological factors prevailing at the time, and the death-rate from week to week. It will be observed that in the absence of rain, and at a comparatively low temperature, the mechanical effect of fall in the amount of wind movement, upon the production of fog and stagnation of smoke, forms an approximate ratio of fog-measurement.

The noxious qualities of a London fog are largely due to the sulphur contained in the coal used in domestic fireplaces. The carbonaceous and tarry compounds of the smoke render the fog yellow and dirty, but the sulphur acids formed by the combustion of sulphur are at least equally, and probably more, injurious to health. The improved combustion of coal would therefore only prove a



A CHART OF MORTALITY & METEOROLOGY IN LONDON — WINTER 1879-80.

partial remedy. Coal must be deprived of its sulphur as well as of its tarry and carbonaceous compounds to make a less injurious fuel. Hence the most hopeful remedy is the use of coal-gas for heating purposes, and this would seem to be the most probable future of gas, when ousted by electricity as a lighting medium. Pittsburg, from being the dirtiest, has become one of the cleanest towns in the United States by the general use of gaseous instead of solid fuel.

For lighting purposes, candles, oil (vegetable and mineral), gas, and electricity are used. They foul the air, light for light, in the order in which they are mentioned, the first mostly; but as those who use candles and lamps are generally content with less light than those who use gas, and as gas is used wherever a large amount of light is required, this is not so apparent to the senses. The last does not foul the air directly; the first are used when portability is desirable. Illuminating gas is the more or less purified product of coal-distillation, and consists mainly of hydrogen and marsh gas, together with carbonic oxide, ethylene, acetylene, and more or less carbonic acid and other gases, and some sulphur compounds, according to the degree of purification. The danger of coal gas poisoning arises mainly from the asphyxia produced by the carbonic oxide present, which is a dangerous cumulative poison.

The air of rooms contaminated by the burning of coal-gas produces drowsiness and headache. The pallor and anæmia of printers and others who work by gas-light is typical of the effect produced by long-continued and habitual exposure to the products of gas combustion. Gas products, together with other causes, by lowering the vitality, tend to render those exposed more liable to bronchial affections, and doubtless share with cold the responsibility for the ill consequences of passing from the close to the open in certain seasons.

In heating interiors by open fire-grates, ventilation as well as warming by radiation produces a constant movement and change of air. Close stoves tend to dry and overheat the air, and currents of air passed over hot surfaces and supplied through tubes are also apt to be delivered burnt and dried, a condition of the air prejudicial to general health

and to the mucous membrane of the air passages. Pipes heated by hot water dry the air less and do not burn it, low-pressure steam being equally useful for this purpose.

Putrefaction and fermentation are the natural processes by which organic matters are split up into their elements. Decomposition is accompanied by the evolution of various gases, the production of intermediate compounds, and the multiplication of low forms of life. These prove injurious to health if permitted to accumulate in the proximity of habitations, and therefore the rapid removal of organic waste matters beyond the precincts of towns is a necessary precaution.

Sewer and drain emanations may carry with them not only many gases, the effects of which have been already considered, but also compound organic vapours and substances of highly offensive odour; and movement and fermentation may project into the air living and dead organic matters that may be carried with the ascending vapours. Amongst these, micro-organisms of various kinds are found; in the presence of moving water the number is reduced, but with stagnation and dampness of the surface multiplication takes place. In well-constructed and well-flushed drains and sewers the sewage is carried away before perceptible decomposition sets in, but the internal surface of a sewer retains a margin of decomposable slime adhering in a broader or a deeper layer, according to conditions. In the hot, dry weather organisms are found in greatest numbers, a result to be expected.

The opening of old sewers, drains, cesspools, and privies has suddenly caused serious and even fatal poisoning, probably more from the poisonous gases than any form of living contagion, and occasionally from asphyxia. The mephitic gases, in less severe cases, have produced more or less vomiting and diarrhœa. This is no uncommon experience. Continued breathing of air contaminated with sewage gases, especially in sleeping-rooms, produces serious impairment of health, children suffering most markedly. Impairment of appetite, languor, diarrhœa, headache, vomiting, sore throat, more or less continued fever, possibly ultimately a typhoidal condition, occur even in the absence of the specific disease. Sore throat is a well-recognised result

of bad drainage; in the present state of knowledge it is impossible to say definitely whether this is always infectious or not, sore throat, like diarrhœa, being the accompaniment of many conditions of ill-health.

Sewer men suffer more from rheumatism and diseases associated with dampness, and not specially from the diseases attributed to sewer gas; but the original robust health of the men, together with the fact that the walls are damp and retain wafted matters, and that the men traverse the sewers temporarily rather than live or sleep in them continuously, modify the conditions under which they are exposed.

There can be no doubt whatever that sewer gas may produce sore throat, diarrhœa, and typhoid fever, and that patients with open wounds and lying-in women may derive from this source erysipelas, pyæmia, septicæmia, and phagedæna. Pneumonia has also been attributed to this cause.

The air of marshes is rendered impure by the decomposition of vegetable matters in water and soil, and gives rise to miasms producing the various forms of malarial fevers. Ill results to health have not been measurable from the effects of the malodorous emanations given off from polluted rivers, from the effluvia of the animal organic materials employed in various manufacturing processes, such as fats and bones, or from dead animals. And although the air of vaults below churches has in past years proved prejudicial to those assembled above, vaults and graves in cemeteries have not been proved to produce untoward results upon the air, but analogy would point to them as prejudicial. Manufacturing processes are the cause of the discharge of innumerable gases and effluvia into the air, and are dealt with as trade nuisances liable to be prejudicial to health.

Water is found in more or less movement in the sea, estuaries, rivers, large and small, brooks, ditches, and canals. The beneficial effect of the proximity of the sea upon health is generally recognised, but in estuaries at the mouths of large rivers conditions less favourable to health are set up. Fogs are common in such situations, and if an estuary be extensive and shallow, with shoals and banks alternately covered and exposed, the humidity is increased, and under the influence of high temperature unhealthy

miasms are produced. Instances of unhealthy climates of this type are numerous in tropical regions at the mouths of both large and small rivers where malarial diseases are endemic. The beneficial effects of movement upon impure water in diluting, aerating, and oxidising organic matters are apparent in the comparative condition of purity in which a turbulent river may be found several miles below a town discharging refuse into the stream. The greater the rapidity of the flow, and the more broken the surface, the greater the degree of aeration and brightness of the water, and the less mud and fine *débris* are deposited in the bed. Contrast in this respect the hillside torrents with the field ditches. In canals the movement is as a rule very slow, and where they pass through towns the jetsam and flotsam and the accumulation of deposit by which the water is fouled are probably only prevented from injuring health by the free play of air over the surface.

It depends upon the depth and area of lakes whether they produce an effect upon the climate of a locality, or not; if extensive and deep, an insular climate may prevail in their neighbourhood. Collections of water when shallow, as in swamps, lead to vegetable decomposition, and have the effect of marshes in a modified degree. Stagnancy, having the opposite effect to movement, is prejudicial to water as a source of supply for consumption; hence ponds are undesirable sources for these reasons, and also on account of possible pollution near habitations.

The sources of potable water may briefly be enumerated as from rainfall, upland surfaces, streams, springs, and wells. The waters vary in composition, according to the source whence derived. One of the most noticeable variations is the degree of hardness. Certain soft waters are liable in contact with lead to dissolve the surface and produce lead-poisoning; rain water and upland surface waters, especially if peaty, then become dangerous. Shallow well waters are liable to pollution derived from the surface, and also through percolation below the surface, from cesspools and decaying animal and vegetable matters. The purity of springs depends upon their distance from sources of possible pollution.

The amount of water necessary per head per day is

usually estimated at from twenty to thirty gallons, including domestic purposes only. In bulk a water-supply is usually stored in reservoirs carefully constructed with regard to height for pressure, and well protected from possible pollution, but in detail the arrangements for storage in domestic cisterns are commonly defective, and permit of pollution by inattention to periodical cleansing, and by insufficient protection from access of polluted air of the house, or of sewer-air, or of various other forms of pollution.

Insufficient supply of water is indirectly a fertile source of disease, leading to uncleanliness of person and habits, of the dwelling and its surroundings. Insufficient flushing of sewers and drains is provocative of the spread of typhoid, cholera, and diarrhœa.

In water are found in solution gases, mineral salts, and soluble vegetable and animal matters; in suspension particles of mineral, vegetable, and animal origin, and living organisms. The most injurious pollutions of water are the organic matters from animal sources, especially excremental matters; in a less degree vegetable matters prove detrimental to health; and in a still less degree some minerals act prejudicially. Lead has already been mentioned as a cause of poisoning which occurs not unfrequently. Other metallic poisons have been found on rare occasions to have gained accidental admission. Goitre, calculi, and diseases of bones have been attributed to the use of certain waters, but without any very exact evidence. Dyspepsia may supervene upon the use of very hard waters, and be accompanied with the manifold symptoms peculiar to that ailment. Vegetable matters suspended in water may cause diarrhœa, and the same symptoms may be produced by animal contaminations. Animal pollution, besides giving rise to diarrhœa and dysentery, may communicate various specific diseases, such as malarial diseases, enteric fever, Asiatic cholera, these diseases being dependent upon the presence of specific micro-organisms. From this source are mainly derived also the entozoa and the hæmatozoa infesting man.

The contour, elevations, and depressions of the surface of the soil, and their depth and extent, influence the conditions of local climate. Enclosed valleys are generally less healthy than hills, on account of the stagnation of air, the

greater humidity, the higher temperature, and the greater luxuriance and rankness of vegetable growth.

The effect of trees is to obstruct the rays of the sun from above, and evaporation from the ground below, lowering the temperature and increasing the humidity, and their absence produces opposite results. Belts of trees sometimes check cold winds and malarious currents of air, but in the presence of increased moisture, decaying vegetation, and higher temperature, the stagnation of the air produced is often injurious. Herbage, on the other hand, being unobstructive to air currents, is always beneficial; it greatly lessens the absorptive power of the soil for heat, offers less obstruction to radiation, and reduces the reflection of light.

Dense soils are better conductors of heat than loose soils, the imprisoned air in the interstices diminishing the conducting power, and consequently also loose soils are subject to greater extremes of temperature near the surface, but to less penetration. The colour of the soil, as of other objects, influences its absorptive and reflective powers of heat and light. Clay soils are cold and damp, and are associated with rheumatism and similar diseases. Higher temperatures of the soil combined with moisture are associated with malaria and cholera. The effect of drainage upon the soil is to cause a marked rise of one, two, or even three degrees in its mean temperature, and a greater equability, because there is less loss of heat by evaporation, and the superfluous moisture in winter and in summer is drained away below the surface. The absorptive power of a soil for water depends upon its interstitial capacity. Roughly, dry sand absorbs about one-third of its own weight, dry mould about one-half, dry clay its own weight, and peat-moss more than twice as much.

The geological nature of the soil exercises an indirect influence upon its salubrity, dependent upon the degree of permeability. Soils even of the same geological formation differ in permeability, and it would be misleading to class a particular formation as pervious or impervious under all circumstances. Generally speaking, impervious soils, sloped to drain away, and soil pervious to a depth of twenty feet or over are not unhealthy; and the reverse conditions, when

associated with stagnant air and water and excessive vegetation, are prejudicial to health. The sands, gravels, and chalks may be cited as the more pervious, and the rocks and clays as less pervious formations.

Soil may be composed of mineral, vegetable, and animal matters of various kinds and proportions. The mineral constituents of soil, when insoluble, have mainly a mechanical effect, and when soluble impregnate water, and are carried away or form new combinations. The vegetable matters may be deposited in masses, or may be broken up into larger or finer particles, or may undergo disintegration and decay, and become incorporated with the soil. Subjected to heat and moisture, a soil extensively impregnated with vegetable matter becomes the hot-bed of malaria. Under natural conditions the amount of animal matters in soil is small and of no great moment, but in proportion to the aggregation of men and habitations the amount increases to a dangerous degree, and is one of the foremost causes of disease in the neighbourhood of habitations.

Animal and vegetable pollution of the soil leads to putrefaction, nitrification, and vegetable growth. It has been hitherto held that putrefaction was a chemical action only, but recent researches have shown that numberless microbes are concerned in the process, and without these micro-organisms organic bodies retain their form. It is recorded that the bodies of dead monks deposited in the caves of certain monasteries situated in the Alps, under the combined influence of a low temperature and a dry air, remain undecomposed, and merely undergo desiccation; the process of embalming preserves mummies from the disintegrating effects of micro-organisms, and the mammoth embedded in ice retains for thousands of years the form that under exposure to the air is in a short time destroyed by putrefaction. Nitrogenous organic substances are not only subject to the disintegrating action of the air, but microbes take an active part in converting organic nitrogen into nitrates.

In cultivated soils microbes are active agents of nitrification, some forming nitrates, others nitrites. Not only do micro-organisms peculiar to the soil carry on this process, but pathogenic microbes also. Heræus mentions many forms capable of oxidising ammonia to nitric acid, amongst

others the typhoid and anthrax bacilli.[1] Petri found that the common bacillus of Koch reduced nitrates to nitrites, and water bacilli also possess this reducing power. Some pathogenic microbes live and multiply in the soil, and many are affected by telluric conditions—for example, those of malaria, anthrax, tetanus, typhoid, cholera, dysentery, yellow fever, and plague.

Manured soils, especially if manured with excreta, abound in microbes; so also do the soils of sewage farms, burial-grounds, and all places where organic refuse is deposited, such as made-soils. The latter are especially dangerous, because made sites are frequently used for building purposes. It is held that after free exposure to weather during three or four years the impurities of made-soils become innocuous; nevertheless, it is a safe precaution to render the basement of houses impervious to ground-water and ground-air.

In connection with dampness of soil, it must be borne in mind that the amount of evaporation is dependent upon the amount of surface exposed; the greater the number of points in contact with the air the greater the evaporation. Consequently there is greater evaporation from a loose surface than a plain one, from wet moss than from wet soil, and from wet soil than from the surface of water. With increased evaporation there is increased humidity of the air and decrease of temperature, and this explains the improvement that takes place in local climatic conditions by the conversion of a swamp into a lake.

Inversely, the conversion of a swamp into dry ground by drainage, and the introduction of agriculture and arboriculture, not only affects the climatic conditions, but also the social and health conditions. It has mitigated the incidence of, or permanently freed many districts from, malaria—notably, on a large scale, the fen districts of this country and the Landes of France. Chambrelent, the famous French engineer, has converted the latter, which were formerly vast swamps, into a district of farms and plantations.

Every kind of soil is found to be more or less damp as we dig downwards; and in most soils, as we descend, we reach a stratum saturated with water. This stratum contains no air in the pores that exist so abundantly

[1] *Zeitsch. f. Hyg.*, vol. i.

in most soils. The water which excludes the air from the pores is the ground-water. The soil above it is permeable to air and water, and is spoken of as damp, as distinguished from saturated. This soil must be superimposed upon a stratum that is impervious to water, else the ground-water would sink. A marsh is an area the ground-water of which rises to the surface, and the impervious substratum prevents it draining away. It is a water-tight basin filled with peat and saturated with water. Instead of rising to the surface, as in a marsh, the ground-water may rise to any height below it, but the higher it rises the damper the overlying soil will be.

Pettenkofer attributed outbreaks of typhoid fever at Munich to the fluctuating level of the ground-water. He concluded that a polluted soil of a certain temperature containing a specific micro-organism, under the influence of the moisture remaining after a fall in the ground-water, gave rise through the soil to outbreaks of enteric fever. But Buchanan has pointed out that the contamination of the well-waters might take place, and the contagium be conveyed in this manner by the ground-water rather than by the ground-air.

In the same way as ground-water fills the interstices of the soil from below, so ground-air fills them from above, there being a point at which they meet, this point being the level of the ground-water. With the fluctuation in the level of the ground-water the depth of the ground-air increases or diminishes, and as this depth is decreased the more superficial layers of ground-air are forced upward and escape. When the subsoil water reaches the level of the surface the ground-air no longer exists, and the condition of a marsh is produced, to be in its turn displaced by a lake if the level of the water be raised still higher. The extreme conditions of the lake or water at its highest level, and of deep ground-water or water at its lowest level, are more healthful than the intermediate conditions, a water surface and a dry surface being less favourable to low growths than a moist surface of the soil, and especially an alternately moist and dry surface.

The ground-water, when near the surface, by capillary attraction maintains the soil above in a condition of damp-

ness, and in the presence of certain temperatures and of vegetable organic matters forms the breeding ground of malaria.

Buchanan[1] demonstrated the direct relationship of mortality from phthisis to height of ground-water. The lowering of the ground-water level reduced the phthisis mortality from one-third to one-half after the laying down of drainage systems in many towns, notably in the city of Salisbury.

Mr. Matthew Adams, Medical Officer of Health for Maidstone, Kent, finds that the rise and fall of the subsoil water is coincident with the increase and diminution of diphtheria in the district during 1888, 1889, and 1890. This, he explains, may take place by the development of diphtheritic organisms in a soil contaminated by soakage of filth at a point just above the ground-water level, a temporary rise in level expelling them into the outer air, and a permanent high level drowning them. Mr. W. H. Power and Dr. Ballard infer that a high level of subsoil water, maintaining surface dampness by capillary attraction in a contaminated soil at a certain summer temperature, promotes the growth of organisms presumed to be the cause of epidemic diarrhœa.

[1] *Rep. Med. Off. Privy Counc.*, 1866.

CHAPTER IV.

BIOLOGICAL AGENTS.

As the inorganic elements, prominently warmth and moisture, form the warp, so organic bodies, the vital forms of the vegetable and animal kingdoms, constitute the weft of environment. In this complex web are interlaced the two sets of conditions that in their totality overspread and surround each individual organism, conducing to its well-being or the reverse. It is only since the increased study of biology that the influence of organic life in the production of health and disease has assumed an importance equal to that of the elements themselves. So short and sharp has been the revolution in vegetable and animal pathology that even experts are adrift from generalisations in the transition from a purely physico-chemical to a bio-chemical pathology, and time must elapse before the arrangement of facts, the deduction of principles, and the construction of generalisations, can reach the full stage of comprehensive exposition.

The influence of organic life upon vegetation in the production of disease, so admirably recorded by Charles Whitehead in his Annual Reports to the Board of Agriculture upon injurious insects and fungi, presents an aspect of the prevalence of pests under certain conditions which may afford a clue to the behaviour of other parasites under similar conditions. Darwin beautifully traced the links of relationship through cats, field mice, and humble bees to the fertilisation of clover, and it is not unreasonable to assume that the greater or less prevalence of particular forms of animal and vegetable life have equally important and link-like bearings upon the growth and multiplication of organisms injurious or the reverse to humanity. The effect of season upon human communicable diseases cannot be

altogether accounted for by temperature and moisture. Analogy would lead to the inference that no species of organisms are exempt from the destructive effects of enemies. It is a comparatively easy effort to attribute vital changes to simple physical causes, but the threshold is yet scarcely crossed of the effects of biological influences. The influence of plants and animals upon man, and the influence of these again upon one another in the rapid multiplication and crowding that takes place in the growth of modern cities, and the methods of modern breeding and cultivation, produce results of greater complexity than ordinary physical phenomena.

Entomology, helminthology, micology, and bacteriology are disclosing facts that have hitherto not been assumed to have a common bearing, but that in the light of more recent researches play a most important part in the vicissitudes and metamorphoses of injurious agents.

One form of life destroys another form either by devouring it as food, or by practically extracting food from it, or competitively depriving it of food, and this form of life again lives upon other forms, and so on. A physical factor, therefore, more propitious to one form of life will cause its greater multiplication, and consequently produce greater devastation of another form. A cold winter destructive to insectivorous birds prevents them destroying the grub of insects which develop in greater numbers in the spring, and commit greater havoc. A cold spring is favourable to the aphis, that destroys the hop-plant; but warmth and drought setting in are favourable to the multiplication of lady-birds, that destroy the aphis. The large white butterfly lays its eggs upon the leaves of the oleaceous plants; in a few days the larvæ or caterpillars hatch out and devour the vegetables, turning into pupæ in the course of a few weeks or less, the pupæ or chrysalis developing into the summer butterflies in the course of a fortnight; but a little more or less warmth or moisture and a parasitic ichneumon cuts short the career of the larvæ, and later another trifling physical variation may favour the multiplication of another parasitic ichneumon that may destroy the pupæ. Doubtless all forms of transmissible and multiplying destructive organisms are subject to similar vicissitudes.

Seasons that are assumed to produce sickness amongst large classes of human beings are often observed to disturb the health and fertility of many plants, and great epidemics amongst human beings are often observed to alter the type of all prevalent diseases not only in man, but also in animals, and among plants.

The failure of crops due to parasites or blight leads to famine; drought and war have led to the same result, and from time immemorial famine has been known to be followed by murrain amongst cattle, and pestilence amongst men, in the forms of typhus, relapsing, and malarial fevers.

But blight, murrain, and pestilence, whatever form they assume, are now classified as organic phenomena rather than as purely physical, and the effects of microscopic forms of life assume corresponding recognition in the causation of the diseases of plants, animals, and men.

By the experiments of Miquel, Carnelley, Wilson, Haldane, Frankland, and innumerable other observers, micro-organisms have been discovered in all places and under all conditions, with extremely few exceptions. They are found in air from all localities, with the exception of the open ocean and mountain summits, and vary in number according to time and place, season and climate. They are most numerous in warmer weather in the open, and in colder weather in interiors, rise of temperature being a factor favourable to their multiplication, and reduced movement of air causing their accumulation. They diminish in numbers with the increase of distance from towns and habitations, and with increase of elevation above ground level. They fall and settle in still air, and cling to surfaces, especially if rough and pervious. Rain washes them from the atmosphere to the surface of earth and water, and any disturbance of the surface projects them again into the air; this takes place more readily from dry surfaces.

Although large numbers of different varieties of micro-organisms have been recognised, the varieties that are pathogenic to man, and the active cause of disease, are comparatively few in number. Any estimation therefore of the number of micro-organisms in the air of a locality is no guide to the degree of injury to health that they may cause, although the germs of disease may be easily carried into the

air from refuse and fæcal accumulations, and infected persons and objects. The influence of micro-organisms upon health depends rather upon their pathogenic power than upon their number.

By analogy it has been presumed that microbes may be carried immense distances in the spore stage, since it is well known that desert sand and volcanic dust, which are comparatively heavy particles, are carried hundreds, if not thousands, of miles, and the seeds of various vegetable forms are also carried in the air to great distances, and fall and fructify on favourable soil far from the place of their origin.

Microbes are almost always present in water, but the numbers and varieties are liable to great variation. They are mainly, with rare exceptions, saprophytic. Bolton[1] and P. F. Frankland[2] have shown that certain varieties are widely distributed, and even in the comparative absence of organic matter multiply with such extreme rapidity that they rapidly outnumber all others. Many saprophytic forms do not multiply in *pure* water, nor do any of the pathogenic microbes. The latter generally require a considerable degree of impurity to supply nutriment for their multiplication. But they retain their vitality a long time, ready to spring into an active condition when transferred to a suitable nidus. Anthrax bacilli will live about six days, typhoid bacilli fourteen to twenty days, if spore-bearing thirty to ninety days, cholera bacilli eight to fourteen days (Flügge).

In the presence of large numbers of saprophytic organisms the pathogenic varieties have a much shorter term of life, being outnumbered and deprived of nutrition. The number of microbes present in water depends upon the temperature and the degree of stagnation of the water. The pathogenic forms may gain access to wells from the surface, or below the surface by fissures, or by the ground-water if the soil be exceptionally pervious, or the source of derivation near at hand. They may also with facility gain access to stagnant pools, muddy river banks, and flooded fields, which under favourable temperatures may be found suitable for their multiplication. Koch demonstrated the presence of cholera bacilli in the water of Indian ponds

[1] *Zeitschr. f. Hygiene*, vol. i., part 1. [2] *Proc. Roy. Soc.*, 1886.

or tanks, probably harbouring and multiplying in the banks.

The soil is the main nidus of microbes; they fall or are thrown or washed on to the surface, and after passing into the air again return to it. Cultivation experiments have disclosed immense numbers of micro-organisms, not only in mould and earth, but also on the surface of road and foot ways. Animals inoculated with surface soil yield a high percentage of cases of disease, especially tetanus and malignant œdema. Organisms are especially numerous in the superficial layers, and in layers in contact with air, water, and organic matters, as in cesspools, but the effects of filtration through soil in straining them off does not permit any great penetration, as ascertained by Koch. In fact, the number decreases with the depth, so that at a depth of from one to three metres, according to the structure of the soil and its condition, microbic life ceases.

That pathogenic microbes, as a class, do not multiply within the soil must be accepted as the negative result of experiments, but it is very probable that the surface soil more or less aids their preservation and distribution, especially by means of the dejecta, as vomit, excreta, discharges, etc., falling upon the soil. There are reasons for believing that anthrax and actinomycosis are diseases that may be derived from herbage infected by animals when grazing; from animals they may certainly be communicated to man, and probably through the soil the vegetation may be again infected, and in its turn again start a fresh cycle of contagion.

The basement soil of a house may be infected with pathogenic or saprophytic organisms. A house situated over a given area of soil, the surface of which is more or less pervious, induces an upward current of ground-air, which varies in purity according to the condition of the ground. If at the same time the ground-water level be fluctuating, and be within a few feet of the surface, so that the layers above are maintained in alternate condition of dryness and moisture, all the factors are present for the discharge of the polluted ground-air into the dwelling.

Even under adverse conditions, life in some form or other flourishes, and all forms of life have their place in nature.

Doubtless, as dirt is but matter in the wrong place, so too other material causes of disease are but wrongly placed matters, whether dead or living. The putrefactive germs fertilising the soil in the open for the production of food, and for the sustenance of life, become destructive of life when transferred to the human organism through the open wounds found in the surgical ward of a hospital.

Numerous observations have been made of the presence of one species of organism preying upon another, or outnumbering it, and holding it in check under particular physical and chemical conditions. The arrest of the development of certain forms of bacteria has been produced by implanting certain others. This struggle for existence amongst the lower forms of life is continually benefiting the higher. Altered physical and chemical conditions produce results indirectly, through altered organic conditions as powerful as, if not more powerful than, the direct physical effects themselves, and these conditions must be considered as affecting organic life generally, and not restricted to the direct and immediate results upon man. With this idea in mind the influences of light, heat, air, water, and soil, as they vibrate and reverberate through organic life, must be considered as demonstrating the interdependence of all organisms in the production of health and disease.

Of ecto-parasites as conveyers of disease, and as the means of introducing disease into the tissues and blood, our knowledge is as yet scanty. Flies of various kinds doubtless convey septic microbes to abraded surfaces where they may be absorbed. Mosquitoes have been found infested with filaria, and probably in piercing the human cuticle they introduce the disease into the body of man. The Texas or Spanish fever that attacks cattle in the Southern States of North America is now known to be communicated by means of the parasitic ticks infesting the animals.

Wild animals keep at a distance from human communities, and their opportunity of communicating disease to man scarcely exists, although their direct injury to vegetation, domestic animals, and the life of man may in some quarters of the globe be considerable. Domesticated animals, on

the other hand, communicate disease both directly and indirectly. The influence of such animal diseases as anthrax, actinomycosis, hydrophobia, tuberculosis, and others upon man and upon other animals are engaging the attention of a host of observers, and the origin and spread of diseases among animals are receiving the close attention of veterinary authorities and breeders, who are acquainting us with their relationships, and pointing the modes of prevention.

The evil effects that may be produced by man upon man are vividly depicted in the certain advent of typhus fever in the presence of overcrowding, and the accompanying unhealthy conditions. From the time of the famous Black Assize, through the seventeenth, and especially through the last century, this disease committed its ravages, unmitigated till the fatality of increased density of population began to be appreciated. Overcrowding is now recognised as directly raising the mortality by pollution of the air, water, and soil, the infant population being more sensitive to its effects. As disease breaks out and spreads amongst the lower animals in overstocked preserves, so does overcrowding in towns lead to a similar result in man.

The excreta of man and animals may convey the contagia of the specific diseases, and contaminate soil and water as well as the air, being dispersed in various directions during decomposition. In closely-confined places in the proximity of dwellings, surfaces and soil polluted by excreta and other decomposing organic matters may form the breeding ground of the contagia.

There is scarcely any act or relationship of a man in a large community but bears not only upon his own health but also upon the health of others. His food, clothing, occupation, and habits, have their indirect as well as their direct results. The removal of filth and the supply of pure air, water, and food are necessitated more by the organic life they harbour than by mere chemical composition. Although, taken in the aggregate, the vast quantity of organic life thus harboured is mostly beneficial as resolving matter into its elements, yet the nidus is ever ready to receive and fructify insidious diseases, the germs of which must of necessity be constantly introduced into it from

without by a community the members of which are ever in movement.

As in succeeding parts of this book the subject of communicable diseases will be more fully entered into, it has only been necessary here to foreshadow the direction of recent pathology, and to emphasise the fact that it becomes more and more necessary to study human pathology in conjunction with the diseases of animals and plants. But our knowledge of comparative pathology is not sufficiently complete in details at the present moment to furnish more than an outline of its general bearings; and the various branches dealing with the diseases of plants, of animals, and of man, as yet work too independently to trace the connection of many coincident or consecutive outbreaks of diseases through the organic world. It is for the public health service in the future to take note not only of physical influences and chemical media, but also of the health conditions prevailing amongst all organic life, and their influence upon the health of man.

PART II.

COMMUNICABLE DISEASE.

CHAPTER I.

CAUSATION.

The passage from health to disease is by a continuous process of change, in which there is no absolute line of demarcation, so that disease strictly includes every deviation from the normal structure and function of the body. Those disturbances of healthy equilibrium that are of an irregular or indistinct type are by common usage spoken of as ill-health, a half-way house and predisposing cause to sickness; the functional and structural changes which manifest themselves as symptoms becoming more pronounced, and the chain of effects more distinct, ultimately range themselves as diagnostic of definite disease.

But the chain of effects and their causes have been the results of medical observation and research through the centuries, and our present knowledge has only been reached by slow stages. Modern conceptions of disease are based upon modifications of older ideas, a survey of which renders many aspects clearer that otherwise would be unintelligible.

The ancients recognised the incidence of diseases upon persons, families, and peoples, regarding them as personal, hereditary, and pestilential. An account of the differentiation of diseases through the ages down to the present time, and the effects of the acquisition of pathological knowledge, would embrace in its entirety a history of medicine.

But, as specially bearing upon public health, the growth and direction of the knowledge of pestilential diseases is of more material interest, particularly as to the mode of their extension and prevention.

The earliest recognised diseases attacking numbers of individuals consecutively, or simultaneously, were the leprosies and the plagues. There is much confusion in the meaning attributed to "leprosy," but the late Erasmus Wilson regarded it as a generic name for skin diseases, and the probability is that the Hebrews so termed all the chronic eruptive diseases, whether local skin diseases or general constitutional diseases, which in the course of time came to be distinguished from each other. The venereal diseases were early differentiated, but even to the Middle Ages true leprosy and elephantiasis were confused under the term *lepra*. Dr. Greenhill attributes this to the error of Constantinus Africanus in translating an Arabic work of the tenth century. At the beginning of the sixteenth century an inspection of the overcrowded leper hospitals of France and Italy disclosed the fact that by far the greater number, and in some cases the whole, of the inmates were found to be suffering from various skin diseases, and not from true leprosy. Hirsch states that it was not until the middle of the eighteenth century that true leprosy and elephantiasis were scientifically distinguished. This single illustration of the want of accurate differentiation in the diagnosis of a conspicuous, and at that time widely-spread, disease, renders it readily understood how little was known of communicable disease down to the Middle Ages, and of the little known how the knowledge failed to be spread and utilised.

As to the extension of leprosy, Dr. Armauer Hansen, of Bergen, is convinced that contagion rather than inheritance accounts for its prevalence, and that hereditary predisposition only plays a secondary part in its transmission. He relies upon isolation to eradicate the disease, and adduces many years' statistics to show that this course is diminishing the prevalence of leprosy in Norway.

All sudden and acute febrile diseases, both eruptive and non-eruptive, appear to have been included by the Hebrews under the term "plague"; and even leprosy is sometimes spoken of in the Bible as a plague of leprosy, the

tsâraath of the Hebrews translated as *lepra* meaning a stroke or stricken. The true bubo-plague appears to be of remote antiquity, but it was not until the sixth century that authentic descriptions of epidemics of the disease were recorded. About the same time small-pox appeared in Europe, although it had been known in Asia from remote periods before the Christian era. There appears to have been more or less confusion between small-pox and other forms of acute eruptive diseases, which were regarded as modifications of the small-pox eruption; and during the Middle Ages, when small-pox came to be known as variola, the modified eruptions that failed to develop vesicles were differentiated as morbilli, according to Hirsch, wrongly held to be measles. About the year 1526 Ingrassias of Naples differentiated scarlet fever from morbilli; but it was not until 1760 that Sydenham distinguished measles, and in 1865 rötheln or German measles was also recognised as a distinct disease. It was not until 1767 that chicken-pox was observed by Heberden as a disease distinct from small-pox, and a little later that cow-pox was so recognised by Jenner.

The non-eruptive febrile diseases were well known prior to the time of the Romans, who erected statues to the goddesses Febris and Mephitis. The proximity of the Pontine Marshes made them familiar with the malarious diseases produced by the vapours of the Campagna even to the present day. Whilst the more severe attack of fever was known as *febris*, the lesser was termed *febricula*. In the eleventh century typhus, which committed such fearful ravages during the succeeding centuries, appears to have been first recognised as a distinct disease; it was only in 1860 that what has been termed typho-malaria received that distinctive name in America. The first settlers in the West Indies, at the beginning of the sixteenth century, experienced a high fatality from severe forms of malarial fever; but yellow fever was not differentiated until 1635 in Guadeloupe, and since then has also been known from time to time as bilious remittent fever, dengue being first recognised in 1780.

In temperate regions fever was a generic expression, which included malaria and typhus (with its many synonyms) during the Middle Ages, until relapsing fever was

differentiated in 1739 and the subsequent years of its ravages in Ireland and Scotland. Between 1814 and 1830 typhoid or enteric fever became more and more recognised as a distinct disease from typhus, although even until 1868 typhus, typhoid, and continued fever were not classed separately in the official statistics of this country.

The diarrhœal diseases have been known from remote time, and a rough distinction appears to have existed between the Asiatic form of cholera, cholera nostras, dysentery, and simple diarrhœa; but Asiatic cholera did not appear in Europe until the eighteenth century at the earliest estimate, and the great pandemics did not occur until the present century.

Glancing back historically, we thus find that leprosies, plagues, animal parasites, malarial and venereal diseases, have been known from remote antiquity. The diarrhœal and puerperal diseases, small-pox, ophthalmia, mumps, cynanche, and possibly influenza, were known at the commencement of the Christian era. Passing through a long benighted period, in the eleventh century typhus was recognised, in the fifteenth morbilli, followed by scarlatina and whooping-cough in the next hundred years, yaws and yellow fever a century later. The eighteenth century was productive of chicken-pox, cow-pox, dengue, elephantiasis, madura-foot, measles, oriental sore, relapsing fever, and carbuncle. The first half of the present century saw the differentiation of cerebro-spinal fever, glanders, diphtheria, enteric fever, rötheln, typho-malaria, and more recent years have seen the recognition of actinomycosis, anthrax, pneumonic fever, and other diseases.

The process of differentiation is still proceeding, new diseases are from time to time recognised, and old ones split up into two or more new varieties. Recently Dr. Thomas Savill recorded[1] a new form of epidemic eruptive disease—a kind of papular and vesicular eczema, with severe constitutional disturbance, that prevailed amongst the inmates of certain London institutions, from July 1890, and caused a death-rate of 12.8 per cent.

A form of pneumonia has also in quite recent years been shown to be communicable. Outbreaks have been

[1] *Brit. Med. Journ.*, Dec. 1891.

reported in several localities, and their infectious nature confirmed and recorded in the more recent reports of the medical officers of the Local Government Board. From Vienna last year a typical instance of the spread of this infectious form of pneumonia was reported. The Grand Duke Heinrich died of pneumonia; his room-attendant was seized with the same disease; then his aide-de-camp, Colonel Kopal; and finally his physician, Professor Oser. There is no finality in the differentiation of diseases.

Although the signs and symptoms of many maladies were known to ancient physicians, and the diseases distinguished at an early period, the idea of their communicability was not grasped until a comparatively modern period. It has been held that the Jews were conversant with contagion, and comprehended the communicability of disease from one individual to another, because they enforced isolation. If the reasons for isolation be carefully examined it will be found that the object was the enforcement of cleanliness and of religious ceremonials, else why were lepers and non-lepers equally excluded from the camp on the ground of uncleanness, or after the touching of any dead body, when rigorous exclusion was also applied, and in other cases when no question of contagion could exist; or, on the other hand, why was the unclean leprous bridegroom allowed to remain with his bride during the nuptial week, according to the Mishna, if the effects of contagion were understood? Sir Risdon Bennett was of opinion that the idea of the Jews recognising communicability arose from the fact that clean and unclean have been held synonymous with contagious and non-contagious, because it was wrongly assumed that mediæval leprosy was the unclean form of *tsâraath*, and the mediæval belief in the contagiousness of elephantiasis was grafted on to this assumption; and although this belief subsequently was discredited in the case of this particular disease, the contagious interpretation of unclean remained. The knowledge of contagion amongst the Jews is all but disproved by Bennett's interesting brochure on the diseases of the Bible, in which he comes to the conclusion that uncleanness did not imply contagiousness, although he admits the possibility that such a manifest parasitic skin disease as the

itch, for instance, that would be healed by cleansing, might have been known to the Levites; and there is strong evidence that the Levitical diseases consisted only of a variety of cutaneous diseases, more or less persistent. The uncleanly habits of the period must have demonstrated the benefit of cleanliness to health generally, and necessitated some discrimination between uncleanness and cutaneous changes of the surface of the body; and how loosely the term "leprous" was applied to the latter is shown by the same definition being applied to the staining or mouldiness of the garment and of the house.

It does not follow that segregation applied to a disease should imply communicability; lunatics and others mentally afflicted were not kept apart for this reason; and Josephus states that amongst certain peoples leprosy was the object of special veneration, and that those afflicted with it were raised to the highest posts of dignity in the state and in the army, had seats of honour reserved for them in the temples, and other privileges.

There is not the least doubt that so far as plagues were concerned, the Jews had no conception but that they were solely due to the wrath of Jehovah. Plagues, pestilences, and famines were classed together as of divine origin. The Greeks and Romans, from the evidences of their authors, resorted to forms and ceremonies to avert epidemics. The erection of statues to Æsculapius and Apollo, the consultation of the Sibylline books, the Lectisterne ceremonies, the nail-driving into the wall of the temple of Jupiter Capitolinus, were remedies applied to epidemics before the Christian era. And subsequently festivals, mournings, and foundings of religious structures were resorted to in order to appease the divine anger, to which the epidemics were attributed, except perhaps those resulting from the injurious effects of marshes, which were known from early periods, for Saint Anastasius propounded two kinds of epidemics, the one provoked by the anger of God, and the other by deleterious miasms. The latter were regarded as gaseous without any idea of communicability. The belief in supernatural agency as the cause of epidemics held sway until the fearful pestilences of the Middle Ages directed special attention to the subject, and certain malarious diseases being more or less

acknowledged as due to the condition of the soil, not unnaturally many epidemics were attributed to telluric influences. Supernatural, astronomical, and cosmic agencies have through all times been assumed to play their parts in epidemics. Arun, a priest of Alexandria in the sixth century, published the most ancient treatise that the Arab physicians possessed, and foretold epidemics by observing the atmospheric conditions. The history of the two principal maladies that broke out in the fourteenth century shows how much prejudice dominated, and how little physicians knew. The dance of Saint Guy in Germany was exorcised by Biblical verses, and the black death, which devastated all Europe during 1348 and the succeeding years, and deprived Venice alone of 100,000 inhabitants, was regarded as a divine punishment. But the vast pestilences of this period were the huge experiments that demonstrated the problem of contagion; and, according to Hecker, in 1374 Viscount Bernabo in Italy was the first to take measures of prevention, acting upon the growing belief in the contagiousness of the plague.

It is from the fourteenth century only that the modern idea of the communicability of pestilential diseases dates, and the preventive measures founded upon this belief bore fruit during this and the following century in the exclusion of strangers, the institution of lazarettos, and the forty days' detention of *quarantine*. Fracastor, in 1546, was the first to fully enunciate the doctrine of contagion according to the modern view. He asserted that a specific contagion was exhaled by the bodies of infected persons, spreading only short distances by the air, but clinging so tenaciously to various objects that it was capable of being transported to unlimited distances, and of infecting whole cities. Although the communicability of plague was established, it has only been by slow steps that one by one other diseases have been added to the list of constitutional affections communicable from one individual to another without direct contact. That this should be so can be readily appreciated from the variable character of the different contagions. Under the difficulties of directly proving the origin of any particular disease, recourse was had to reasoning by analogy, the analogies available being the transmission by

direct contact, as in the more obvious skin eruptions, syphilis and scabies; by telluric influences, as malaria; by winds, as blight, and the effects of dry, hot, and cold winds.

In the face of an epidemic, the tendency naturally is to generalise, and to attribute to one single cause the outbreak of disease, and the greater the suddenness of the attack the more is the appearance of simultaneity rather than of consecutiveness produced. No wonder then that superficial and scattered observation should attribute the spread of an epidemic to any cause rather than that of infection, and when each of the known causes of disease in turn proves insufficient to explain the disaster, to fall back upon "epidemic influences," a convenient term, embracing every form of environment.

Of the epidemic influences the most obvious, and the most frequently cited as cause, has been the atmosphere. Epidemics have been observed from time immemorial to fluctuate with meteorological changes. The influence exerted by these changes upon organic life materially controls the course of epidemics, especially by means of temperature, humidity, and air currents. Hippocrates grasped the physical effects of airs, waters, and places. But although these effects may explain the exacerbation or extension of epidemics in parts, they failed to demonstrate the *materies morbi.*

In the absence of exact knowledge winds have been held, even in the present day, to account for the spread of many diseases to considerable distances, in the form of pandemics. The passages of influenza from Asia through Europe have been attributed to this cause, although the course is more or less in a line opposite to the direction of the prevailing winds. Dr. Bryden expressed the opinion that in India cholera extended beyond the endemic area under the influence of meteorological agencies, and that the epidemic material was carried and distributed by the air, that it was wind-borne, and wherever the wind-currents descended to the surface there produced epidemics. That the epidemics either broke out at once, the material being fully developed and capable of imparting cholera to the susceptible inhabitants, or were delayed longer or shorter periods according

to local conditions influencing the cholera material, which reached the locality in a dormant state.

Telluric agency has, at one time or another, been assumed to be the cause of the spread of a number of diseases: the malarial fevers, and the various forms of bowel complaints, including diarrhœa, dysentery, cholera, typhoid, or, as it was sometimes called, abdominal typhus, rheumatism, and many other diseases. Although malarious diseases largely prevail in the neighbourhood of decaying vegetation and swampy ground, and have been known to prevail in such localities almost from time immemorial, yet they are not confined to such localities. The agues that formerly prevailed in low-lying districts in the east of England have well-nigh disappeared since the improvement in the drainage of the soil, and in various parts of the world the beneficial effects of soil and subsoil drainage have been realised. But many of the long list of diseases formerly attributed to telluric influences have been removed from this category, with increased knowledge of ætiology. In some the soil has been shown to play only a secondary part, and in others to exert little or no influence, except upon the general health.

To food, or the want of food, the ravages of certain diseases have been traced—*e.g.*, pellagra to diseased maize, ergotism to diseased rye, scurvy to the absence of vegetable diet, and famine diseases to want; and such diseases have assumed epidemic proportions. Famine has ever been associated with disease, and hence at times other forms of epidemic disease have been attributed to the same cause, and held sway until such theories have been displaced by controverting facts. Food is notably the vehicle of transmission of many communicable diseases, although the transmission by direct infection of some diseases has rendered such a derivation unnecessary to account for the spread of certain epidemics.

The recognition of diseased conditions, and the knowledge of influences bringing them about, failed to complete the equipment requisite to combat disease, without the detection of the actual cause. Not only were physical and chemical agents credited with causing disease, from early times, but organic life was opined to create disturbances of

health. Previous even to the time of Lucretius, who wrote two thousand years ago, the theory was broached that minute animals were the cause of certain diseases; and Varro and Columella also attributed malarial fevers to the attacks of living organisms. From those days forward similar theories were advanced. Athanasius Kircher in 1671 attributed the fermentations to the action of worms and insects; and shortly afterwards, in 1677, Lœwenhöek, by the aid of improved microscopic lenses, discovered a new world of micro-organic life. Slowly, from this date forward—very slowly, due to the ridicule cast upon exaggerated statements—the microscope disclosed more and more of that world of the infinitely small only previously dreamt of. The construction of the microscopes of Seligues and Chevalier in 1824 gave a great impetus to histology that has advanced with successive improvements to the present day.

As the belief in the supernatural causes of disease gave way to that of natural causes, so extra-mundane or cosmic causes gave way to mundane; and although climatic effects remained as the predisposing and exciting causes of certain diseases, with the irrefutable conclusion that others were communicable from person to person dawned a new era of medicine. Then commenced slowly and hesitatingly the observations of the means by which communicability was effected: immediately—from person to person, mediately—through air, water, food, fomites, and soil.

With the extension of commerce, increased intercommunication, the revival of science, and the wide-spread pestilences of the fifteenth, sixteenth, and seventeenth centuries, a knowledge of the geographical distribution of disease grew up, and more or less knowledge of the behaviour of diseases accumulated.

With the advances of pathology the phenomena of fever were more closely observed, and about the middle of this century Traube and Baerensprung first used the thermometer for the exact measurement of variations in bodily temperature. The researches of Wunderlich and the numberless observations since made have acquainted us with the continued, remittent, and intermittent types of fever, and with the duration and intensity of the pyrexial stages of incu-

bation, invasion, domination, and decline in febrile diseases. So that the temperature curves in many diseases are now the most reliable means of diagnosis, and some diseases may be read as easily upon a temperature chart as music upon a score—amongst others, typhoid, pneumonia, measles, relapsing fever, and ague.

A step in advance at a somewhat earlier period was the establishment by Schwann of the cellular nature of animals and their analogy to plants. Every organised part of the human body is cellular, or derived from cells, and every cell originates from pre-existing cells. The cell is the seat of nutrition and function, and every cell is, taken individually, an independent organism, exhibiting all the characteristics of life. In a complex organism the cells of which it is built up possess distinct and specialised functions, work in association, and produce the combined result characteristic of the whole organism. The cell consists essentially of protoplasm endowed with the power of nutrition, growth, and multiplication. Multiplication may take place by *endogenous growth*, daughter cells appearing within the parent cell, by *gemmation* or budding, and by *fission* or simple division, the last being the most frequent method. Every pathological change implies an alteration in the nutrition, growth, and function of the cells. The properties may be increased or diminished, leading to hypertrophy, atrophy, new growths, and degenerations when of slow progress, and when more rapid to inflammation and the various destructive processes.

A further advance sprang from the cellular theory of inflammation propounded by Virchow, the limitations of which we are now able to comprehend. As Cohnheim[1] defined it, inflammation is the consequence of molecular alteration in the walls of capillary vessels, causing increased adhesion, friction, and retardation of the blood-stream, together with augmented permeability of the walls, resulting in an increase of transudation of serum and corpuscles. Not only may this be brought about by tissue cells, but by every agency by which the chemical constitution of the vessel walls is altered. The same effect may be produced

[1] *Lectures on Pathology.*

by different causes without any dissimilarity in the process of the resulting inflammation.

Simon attributed to contagium the causation of inflammation, especially when of a specific type. Burdon Sanderson applied the term infective or secondary to certain inflammations distinct from the common type. Some ten years later, in 1881, Ogston demonstrated the presence of microphytes in the products of acute inflammations.[1] Thus it came to be established that the result of the attacks of microphytes or the effects of their products, is to set up infective inflammation. The leucocytes become charged with the micrococci, and are discharged as pus, a local result; but should the pus not be discharged, or should the micrococci or their products enter the blood-stream, septic poisoning takes place, or metastatic foci of disease, starting at a distance from the seat of the initial affection, are set up.

Closer observation of the phenomena of the specific fevers led to closer inquiry into the communicable entity. Was the contagium gaseous, as marsh-gas and carbonic acid, or liquid, as venereal secretions and vaccine lymph, or solid, inanimate or animate? Chemistry failed to reveal that which biology demonstrated, the analogy of the course of the specific fevers to the life-history of living organisms. The microscope and the cellular theory paved the way for the germ theory, that communicability was dependent upon a *contagium vivum*.

Ehrenberg in 1828 was the first to observe living microscopic organisms in dust and water. Schwann in 1837 demonstrated their presence in the atmosphere, and their power of producing fermentation and putrefaction; but in 1840 Henle traced the relationship of microbes to infectious diseases, and described the manner in which these diseases were dependent upon vital organisms in these terms:—"If we trace the miasmatic contagia in their action on the animal organism, we find at once, although with many individual differences, a general and characteristic property, which can only be ascribed to living matter—namely, that of multiplying at the cost and by the assimilation of foreign organic material. This conclusion is supported by the course of the great majority of miasmatic contagious

[1] Croonian Lecture, 1891.

diseases. They belong to the group of diseases which I have termed typical, where sharply-defined stages indicate a development of the cause in accordance with definite laws, such as we only find among living beings. . . . In place of the unintelligible view that the diseased body, or the disease itself, forms the contagious material, we have the opinion that the formation of the contagion is a reproductive process, and that the disease is the result of the reproduction of this extraneous being in the organism and at its expense. From this point of view we must interpret the symptoms of the miasmatic contagious diseases. While we must hold that the cause of the miasmatic contagious diseases is a material endowed with independent life, which can reproduce itself after the manner of animals and plants, can increase by assimilation of organic materials, and, growing parasitically on the infected body, can give rise to the symptoms of the special disease; yet the question arises of what the as yet unseen body of this parasite is composed, the result of whose life is so evident and so devastating. It is one of the laws of human phantasy that we must ascribe to the contagium, as soon as we reckon it to be something living, one of the forms which the organic world presents to our senses; hence in the earlier childish times of research one thought of insects, and when the microscopic animals were discovered, the infusoria could, with still better grounds, be accused of being contagium and miasma. At the present time, since the conclusions that have been arrived at with regard to the fungus of muscardine (the fatal parasitic disease of silkworms) and similar diseases, it seems more likely that the contagium belongs to the vegetable world, because the extensive distribution, the rapid multiplication, and the tenacity of life of the lower microscopical vegetable beings, as well as the mode of their action on the bodies which they have selected as the seat of their vegetation, present in fact the most remarkable analogies with the infective material of the miasmatic contagious diseases."[1]

So was the theory propounded by biologists, that as helminthiasis was dependent upon animal parasites, specific fevers were dependent upon vegetable parasites, and the

[1] *Micro-organisms.* Flügge. (Watson Cheyne's translation.)

subject of parasitism dichotomised into helminthology and bacteriology.

It is since the commencement of civil registration in this country in 1837 that the nomenclature of the causes of death, and consequently of disease, has assumed more definite shape. A defined nomenclature has made classification possible, and vital statistics, the basis of sanitary science, owe their foundation to it. Simultaneously, pathological research has perfected the recognition of diseased conditions, and improved the accuracy of registration. The advances of pathology have from time to time necessitated revision of nomenclature and classification; but the more rapid strides in quite recent years and the growth of bacteriology have materially altered the bases of generalisation, so that even now the pathology of communicable diseases is passing through a transition stage.

In reaching the present standpoint of pathology the relationship of the various families of diseases is more clearly defined than at any previous period, and it is possible to place them in such juxtaposition as to throw into relief their respective limits.

The causes of diseases are commonly distinguished as predisposing and exciting. Predisposition to disease has already been considered in connection with heredity. The offspring inherits from the parent stem the constitution or diathesis. The diathesis may embrace a predisposition, leading soon after birth or later in life to the acquirement of a particular disease. Such disease, although frequently termed hereditary, is not actually existent at birth, but only the predisposition thereto. Predisposition to disease may also be acquired in after-life, as well as inherited at birth, and this predisposition, again, may be transmitted from parent to offspring. Excluding at the moment predisposition, actual disease may be either congenital or acquired. Congenital disease, with which a child may be burdened in entering into the world, may be a defect of form, as a malformation, or of function, as mal-assimilation of food, or a transmitted "contagium," as syphilis, tubercle, and the acute zymotic diseases. Acquired disease may be due to intrinsic causes dependent upon the functions of the body, as habits, mode of life, etc., and more or less within the control of

personal hygiene, or it may be due to extrinsic causes. These extrinsic causes of disease may be either physical or chemical agents, as climatic, industrial, and others, or the agents may be animate and capable of reproducing themselves in a suitable nidus.

As man, like the lower animals and plants, is capable of harbouring living organisms, macro- and micro-, animal and vegetable, and as these organisms are invariably present in certain diseases, it is now accepted that a large class of diseases is dependent upon a *contagium vivum* as the cause or *causa causans.* As the doctrine of abiogenesis or spontaneous generation has been amply disproved, and the vermicular diathesis is no longer maintained, these organisms must be introduced from without, and be capable of leading a parasitic existence.

CHAPTER II.

PARASITISM.

ORIGINALLY the term contagion signified the communication of a disease by contact, direct or indirect, and infection implied communication without actual contact. The relative meaning of the two terms is still well understood when speaking of a disease requiring actual contact or inoculation to communicate it, in contradistinction to a disease communicable without contact either direct or indirect. The two terms have been so used in Acts of Parliament, but although applicable to well-defined diseases at the two extremes of their classes, there are a number of diseases that cannot be adequately so classed, and hence the terms contagion and infection, although not yet replaced in medicine by more explicit general terms, have ceased to convey the distinctive ideas they originally possessed. In the transition stage that pathology is rapidly passing through many new terms have sprung into use to define the altered conditions, the convenient term "contagium" being still retained as of definite meaning. The communicability of contagium throughout the vegetable and animal kingdom is of such immense importance to the social, economic, and vital condition of man that a full appreciation of its many aspects places a different complexion upon that which, until recent years, was not regarded as a phenomenon of such universal occurrence.

The fermentations by which products useful to man are produced—such as alcohol and vinegar—the putrefactions by which refuse matters are converted into harmless substances or fertile soil, and the infections which destroy life, are all analogous processes due to contagia. All these

contagia possessed the power of multiplication, and were hence assumed to possess vitality.

The researches of recent years into the contagia of various diseases render it unnecessary to defend what is now so firmly established—namely, the dependence of many diseases upon a *contagium vivum* for their perpetuation. The problems now under solution by many workers are the probable dependence upon parasites of many other diseases hitherto recognised by their effects, not classified according to causes, and the differentiation and life-histories of the various organisms lighted upon in the course of those researches. The ground is definitely shifted from the proof of what was but a few years ago known as the germ theory to a higher level altogether. It is now a question no longer of a general theory, but of the variation in the individual factors constituting the apparently universal biological process, that as organic life rapidly builds up organic matter, so may organic life rapidly disintegrate and resolve organic matter into its constituent elements.

Bacteriology in the short space of some fifteen years has sprung into existence as a science. Improved microscopic lenses and methods, combined with the use of aniline and other stains, have rendered the most minute micro-organisms visible, and have enabled their form and structure to be defined. The use of liquid and solid nutritive media and various methods of employing them, the separation of organisms from one another, and the process of pure cultivations, have enabled the characteristics and life-history of each organism to be ascertained.

The causal connection between an organism and the disease associated with it has been established by proving, in accordance with Koch's postulates, that the parasite is found in every case of the disease, that it occurs in no other disease, and that when isolated and after propagation in pure cultivations it can reproduce the disease, and that the parasite can again be found in the tissues of the subject of the reproduced disease. In many diseases of the lower animals complete proof has been afforded, and also in diseases common to man and the lower animals—anthrax, erysipelas, tuberculosis; but complete proof of the causative relation of microbes to human diseases is restricted,

even in those diseases with which a characteristic parasite is invariably found associated; the chain of evidence necessarily stops short of artificially reproducing the disease in man. Analogy also has led to the inference that even in those communicable diseases in which no characteristic organism has yet been isolated, the germ theory still holds good, as in hydrophobia and the exanthemata.

It has been advanced that the advent of organisms found in disease takes place subsequent to the effects of chemical ferments, and exercises no initial causative influence in the production of disease, but this has been disproved in the case of specific microbes.

Thus the subject of contagion in quite recent years has resolved itself mainly into the study of parasitism, and, when viewed by the light of recent knowledge, parasitism reveals itself as a phenomenon extending to both those series of human diseases classed as parasitic and as zymotic, whereas only the parasitic had hitherto been regarded as due to animal and vegetable parasites, and the zymotic were attributed to ferments. Fermentation was regarded as a purely physical and chemical phenomenon, and was so described by Gay de Lussac in the earlier part of this century, and yeast as its chemical product, Berzelius so describing it somewhat later. Liebig looked upon yeast as gluten undergoing chemical change, and inducing an analogous change in the medium around it; and Dr. Farr in 1842[1] introduced the term "zymotic" to designate the epidemic, endemic, and contagious diseases induced by a similar although not absolutely identical process. But subsequently Schwann and Cagniard-Latour discovered that yeast cells were living organisms; and Pasteur demonstrated that yeast was the actual cause of fermentation.

He established the fact that putrefaction and the alcoholic, butyric, acetous, mucous, and lactous fermentations were caused by different varieties of microbes. Tyndall and others confirmed the fact that these micro-organisms were not of spontaneous origin, but must be introduced from without to bring about fermentative and putrefactive changes; and Lister, by their exclusion, obtained his brilliant results in surgery. Although Pollender dis-

[1] *Vital Statistics.* William Farr. Edited by Noel A. Humphreys.

covered the anthrax bacillus in the blood in 1855, it was not until 1868 that Davaine demonstrated it as the cause of anthrax. In his communication to the Académie des Sciences[1] he showed that while, in the then actual position of science, no one would have thought of seeking beyond the corpuscles for the agent of contagion, this visible and palpable agent is an organism endowed with life, which develops and propagates itself after the manner of living organisms. By its presence, by its rapid multiplication in the blood, it brings about in the composition of this liquid, doubtless in a manner similar to ferments, modifications that promptly cause the infected animal to perish. It was from this period that pathological bacteriology commenced to make its rapid advances in experimental demonstration. Koch, and numerous other workers in the field of bacteriology, have within recent years clearly demonstrated that certain specific micro-parasites are found associated with certain specific diseases, and that the growth, multiplication, decline, and elimination of these pathogenic microbes are coincident with the progress of those diseases, and are the actual contagia. The dependence of pathological zymoses upon microbes points by analogy to associating the term "microbic" rather than "zymotic" with parasitic diseases.

From this point of view parasitic diseases would be divided into macro- and micro-; but mere size cannot form a scientific basis of classification, and they are more correctly divided into animal and vegetable. Amongst the latter fall the Bacteria, now considered vegetable rather than animal, from the fact that they are able to derive their nitrogen from ammonia compounds, although, owing to the absence of chlorophyll, they differ from the higher vegetable species in being unable to split up carbonic acid.

Parasitic life is a phenomenon exceedingly widespread through the animal and vegetable kingdom, and it is difficult, if possible, to define its limits, if the beetle on the plant and the louse on the animal, the larva in the fruit and the worm in the intestine, the mould on the bark and the fungus on the skin, be regarded as equally parasitic. Plants, animals, and man each possess their parasitic pathology. The parasites of animals in general, and of man

[1] *Comptes-rendus*, t. lvii.

in particular, are always smaller and weaker than the host from which they derive their food. They may be described as those organisms which lodge upon or in other living organisms, and obtain their nourishment from them, but do not necessarily so pass the whole of their existence. Those creatures which do not feed upon the tissues of the host, but share its food, or merely live upon its surface—called by Van Beneden *commensals*, or messmates—need not be strictly included amongst parasites.

Certain factors favour the invasion of man by a parasite. The parasite must be pathogenic—*i.e.*, find in or on the human body a suitable soil. This soil may be the hair or the skin externally, or internally the mucous membranes, the deeper tissues and organs, or the blood. The parasite must find a suitable mode of transference to its host; this may be immediate, as by contact, or mediate. In the latter case it must be capable of existing for a longer or shorter time in the medium. The medium may be living organisms or dead organic matter, or inorganic substances, as water, air, etc.

Some parasites, both animal and vegetable, appear to be unable to live a free existence, or only to a very limited extent; others appear to be capable of both a free and a parasitic existence for longer or shorter periods; other organisms, again, allied to parasites, appear to be unable to lead a parasitic existence. These differences, which have been described by Leuckart as *constant* and *occasional* in regard to animal parasites, have led De Bary to describe parasitic fungi as *obligatory parasites*, that occur naturally as parasites, and can only be cultivated as saprophytes artificially; *facultative parasites* and *saprophytes*, that may pass part of their life-cycle as parasites or as saprophytes; and *obligatory saprophytes*, that grow in dead organic matter, and are not found parasitically in living vegetable or animal organisms.

Again, parasites vary according to their capacity for development in the presence or absence of air or oxygen. The animal parasites have hitherto in this regard only been considered as possessing or not possessing respiratory organs; but Liborius divided the bacteria into anaërobic and aërobic; these again into obligatory and facultative.

The *obligatory anaërobes* growing only when oxygen is as completely removed as possible from the nutrient medium, as the bacillus of malignant œdema, the *Bacillus butyricus,* etc.; the *facultative anaërobes* and *aërobes* capable of development in varying degrees, both in the presence and absence of air, as the bacilli of anthrax, typhoid, pneumonia, cholera; and the *obligatory aërobes* only capable of development in the presence of air or oxygen, as the *Bacillus subtilis.*

Of the zoo-parasites infesting man a number of varieties are known. They inhabit different parts of the body, the most accessible parts being the most frequented, and more than three-fourths are found on the skin or in the intestines. They pervade either the surface of the body or the internal passages, tissues, and organs, or the blood-stream, and when considered according to habitat are classed as ecto-, ento-, and hæmato-zoa. Those zoo-parasites that merely call upon man for the purpose of rest, food, excretion, or fertilisation have been known as "temporary"; they all possess organs of locomotion, and are all external parasites. On the other hand, those that pass longer periods, or their whole time, with their host have been termed "stationary," and are provided with means of attachment, such as suckers, hooks, etc., and may be either ecto- or ento-zoa.

It will be more satisfactory from the present point of view to consider the ecto- and ento-zoa according to their relationship to the surface, external and internal, and to the deeper tissues, and their mode of attachment and power of progress, as free on the surface, adhering or affixing to surfaces, and burrowing below the surface or wandering into the deeper tissues and organs.

The free ectozoa include those whose residence upon the surface is only occasional and of short duration. Some are provided with wings, as mosquitoes, midges, tzetze, and other kinds of flies; and others are wingless, as the various kinds of bugs and fleas. They also include more particularly certain of those insects known as dermatozoa, such as the head, body, and eyelid lice. Beyond the effects of the presence of these ectozoa, a special interest attaches to the fact that they are generally provided with a boring apparatus, as in the case of mosquitoes, fleas, bugs, etc., by means of which they pierce

the epidermis, and it is at once apparent that they may be the means of conveying and inoculating into the tissues or the vessels highly injurious matters. The mosquito, for instance, is believed so to inoculate *Filariæ* into the blood of man. Dr. Thin holds that the itch *Acarus* may convey the infection of leprosy. Dr. Dewevre suggests that the bug may be the medium of transmitting tuberculosis.[1] Even those that do not possess a boring apparatus, by their facility of flight may readily convey and inoculate injurious matters into open wounds or abrasions of the surface. How far contagion may be so conveyed and communicated has not been ascertained, but the possibilities are great. Ophthalmia, for instance, may be so communicated, and septic organisms be conveyed to wounds.

Those ectozoa that adhere to the surface by means of suctorial apparatus comprise the various kinds of leeches. Like many of the preceding, they feed upon the blood of their host, and are supplied with incising mandibles and suckers.

The ectozoa that burrow beneath the surface give rise frequently to considerable inflammatory symptoms. Those that penetrate the integument are either Arachnida armed with claws, as the various mites, of which the best known are the itch-mite or *Acarus scabiei*, and the pimple-mite or *Demodex folliculorum;* or are insect parasites armed with piercing apparatus, as the *Pulex penetrans* or chigoe, the females of which bury themselves in the skin similarly to the itch-mite; the crab-louse is another of the same kind. Certain Nematode worms also belong to this class; the *Filaria medinensis*, or Guinea-worm, supposed to be the fiery serpent of the Israelites, which penetrates the skin of the feet of negroes; a *Filaria* that invades the lips, *Filaria labialis;* and two that invade the eye, *Filaria oculi* and *Filaria loa*, the latter the eye of negroes.

It is doubtful whether it is desirable to consider the various larvæ of numerous kinds of winged insects, deposited in open wounds and sores, or in the mouth, nostrils, and other open passages, as entozoa, but for the fact that many of them are found in the intestines, and may thus be looked upon as free entozoa.

[1] *Brit. Med. Journ.*, July 2, 1892.

The number of animal forms that may be carried with the food into the intestines is considerable, but although they may pass through uninjured, especially in the ovoid or the larval state, there are few that may be said to live upon their host, and thus be truly parasitic; but some are known to remain for longer periods as true free entozoa. Such are, the *Amœba coli*, a Rhizopod found by Lösch in dysenteric stools, and corroborated as the cause of a form of dysentery by several observers since; certain Infusorians, the flagellate *Cercomonas intestinalis*, observed by Davaine, Laubl, and others, in digestive disturbance; the flagellate *Trichomonas intestinalis*, observed by Marchand, Leuckart, and others, in severe intestinal diseases, and of which another variety, found by Donné, frequents the vagina; the ciliated balantidium or *Paramœcium coli* of Malmsten, found in the diarrhœa of man and of pigs; also *Trichinæ*, previous to migration into the tissues, giving rise to choleraic diarrhœa, are found as free entozoa.

When we reach those entozoa that station themselves in the intestines by means of processes of attachment, we meet with the large and commonly known intestinal worms, or Helminths. It is only a few decades since, that Helminths, or intestinal worms, were held to be of spontaneous generation, produced by a constitutional condition termed *diathesis verminosa.* But like the theory of *abiogenesis*, subsequently raised in connection with micro-organisms, the assumption became untenable in face of the evidence of carefully traced life-histories of the organisms. It is now established that various degrees of disease symptoms are produced by intestinal worms, and that precedent pathological conditions are not the origin of Helminths; but the disease symptoms not being differentiated are still commonly known under the generic term of helminthiasis.

The commoner forms of worms infesting the intestinal canal of man are the tape-, round-, thread-, and whip-worms. The tape-worms include *Tænia mediacanellata*, or *Sarginata* (from the cysticercus of beef), which is the only cystic tape-worm of man without hooks; *Tænia solium* (from the cysticercus of pork); *T. tenella* (from the cysticercus of mutton); and other less frequent *Tænia;* also *Bothriocephalus latus*, the broad tape-worm of

the Continent of Europe (from the free ciliated embryos of some aquatic animal); *B. cordatus*, the Greenland tapeworm (probably from the embryo in fish); the *B. cristatus* (of Davaine), the *B. liguloides* of China (Leuckart). The round-worms known as infesting man are—*Ascaris lumbricoides* (probably completing its life-cycle in the host); *Ascaris mystax* (also found in the cat and the dog); the thread-worm, *Oxyuris* (*ascaris*) *vermicularis*, infesting the bowel from the cæcum to the anus, also found in the pig as *Ascaris suillæ;* and the whip-worm, or *Tricocephalus dispar*, which is also found in domestic animals, as *Tricocephalus crenatus.* Davaine says it is very common in France, and Leidy in the United States. Self-infection may take place with both the latter parasites, the egg-covering being digested off in the stomach, the embryos escaping and reaching maturity in the intestine.

Other Nematodes are found infesting the intestine, the *Anguillula*, or *Rhabditidis stercoralis*, the cause of the so-called Cochin-China diarrhœa, and the *Dochmius duodenalis*, the Helminth that gives rise to a form of tropical anæmia, from the fact that like the leech it feeds upon the blood of its host. It is prevalent in Italy, but particularly common in Egypt and Brazil, where it is a frequent cause of death; the young live freely in water, of which the natives drink. Either this or *Distoma crassum* is supposed to be the cause of the disease known as *beri-beri* by some observers. Tutz has termed it *Anchylostomiasis*, whilst Sir Joseph Fayrer suggests it may be the result of a *hæmatozoon*, and Mr. W. A. Morris considers it of malarial origin.[1] A related parasite, the *Filaria bronchialis*, common in domestic animals, occasionally attacks man. The urinary and vaginal passages may also be the seat of entozoa.

The entozoa that possess the power of wandering into the tissues and internal organs of the body, either by means of boring apparatus or by persistent pressure, or through discontinuities of the surface, are the more dangerous and injurious to health. The *Pentastoma denticulatum*, one of the *Ascarides*, an immature form derived from the eggs of the *Pentastoma tenioides* of the dog, bores into the liver; being of small size, its effects are not so serious, but the

[1] *Trans. of Epidem. Soc.*, 1889.

P. constrictum, which tunnels the lungs and liver, is of larger size, and causes painful deaths in tropical Africa, according to Aitken. The *Distoma hepaticum* is the commonest form of fluke found in man, and, as its name implies, infests the liver; it has also been found in other parts, and in many warm-blooded animals, probably ingested with vegetable food. The bladder-worms, *hydatids*, *cysticerci*, or *echinococci*, appear to be the larvæ of various tape-worms; the *Cysticercus tenuicollis* is the larval stage of the *Tænia marginata* found in the wolf and other carnivora; the *Echinococcus terminis*, the larva of the *Tænia echinococcus* of the dog, common amongst Icelanders, who harbour many dogs. The *Trichina spiralis* bears a close analogy to the *Filaria;* it is found in a number of animals, reaching the intestines by the mouth, and thence finding its way into the muscles, where it becomes encysted. The consumption of raw ham in Germany is a frequent cause of the disease in man.

The most interesting feature of the entozoa is the bearing their life-histories have upon the evolution of the causes of disease. Certain parasites appear to pass their whole life-cycle within their host, and to pass from one host to another; others appear to require to change hosts with the stages of their development in order to attain maturity; others again require to live a free life in order to hatch, grow, and multiply; again, others spend only a short period with their host, and so short in some cases that the difference between their structure and that of closely allied forms is almost inappreciable, so that Leuckart considers that parasites have, by accommodating themselves to the conditions of a parasitic life, in course of time sprung from creatures originally free. Our knowledge of parasites is very fragmentary, but he summarises the known facts of their life-histories in a comprehensive manner.[1]

(1.) The embryos of entozoa lead a free life for some time under an altered form. They are not only capable of free motion, but take in food just in the same way as other creatures.

a. In the course of this free life the young form arrives

[1] *The Parasites of Man.* Translated by W. E. Hoyle. See also Neumann's *Treatise on Parasitic Diseases.* Translated by Fleming (1892).

at sexual maturity, and thus only the sexually-produced descendants return again to parasitism. (*Rhabdonema* (*ascaris*) *nigrovenosum*).

b. The young form itself becomes again a sexually mature parasite at a certain stage of its development. From the commencement it enters its definitive host, and its development ends there; although this happens occasionally, as in the case of *Sclerostomum equinum*, in a provisional situation. To the former class, among others, belong certain *Strongylidæ.*

(2.) The embryos find, in pursuance of an active or passive migration—without ever having led a free life—an intermediate host, in the organs of which they develop into a larval form, which then ends its life-history under various circumstances.

a. The larva migrates, and becomes, after complete metamorphosis, a free-living animal (*Œstridæ* among other flies, *Ichneumonidæ*, *Mermithidæ*, *Gordiacea*).

b. The larva arrives at sexual maturity in its intermediate host without further metamorphosis, as in the *Archigetes* and *Aspidogaster.*

c. The larva remains in the intermediate host, mostly in a passive way (with food). The developmental history in such cases is extended over two different hosts. This is the form of life-history which we discover in the majority of intestinal worms, and may be considered as really typical among entozoa (Cestodes, with the exception of *Archigetes*, *Acanthocephala*, *Distomidæ*, and *Pentastomidæ*). In individual cases there are here certain modifications thus:—(i.) The number of intermediate hosts increases, whilst the larva either migrates of itself and seeks a new host (certain Cestodes), or produces sexually a new generation, which then enters upon a similar change of host (*Distomidæ*). (ii.) The intermediate and definitive hosts become one and the same, when the embryos do not forsake the latter, but simply wander into its peripheral organs, and there develop into larvæ (*Trichina*).

(3.) The embryos pass, whilst they are yet enclosed by the egg-shell, in a passive manner into the intestine of their definitive host, and here complete their further development. To this class belong numerous Nematodes, especially *Trichocephalus* and *Oxyuris.*

From the wandering entozoa to the hæmatozoa is not a wide step; the phenomenon of parasitism passes by insensible gradations from temporary external lodging to more permanent internal invasion. Two hæmatozoa infesting man are known, and their histories have been carefully traced. The *Distomum hæmatobium*, a Trematode worm, discovered in 1852 by Bilharz, lives in the portal vein, and migrates to the veins of the pelvis to deposit its eggs, the female being conveyed there by the male. The male is armed with setæ, by which it is enabled to progress against the blood-stream, carrying the female lying in a long groove upon its ventral surface. This parasite is the cause of the formidable endemic hæmaturia of Egypt and the Cape, the eggs and embryos rupturing the veins in the walls of the ureters. The *Filaria sanguinis hominis*, first discovered in 1872 by Lewis, was shown by Dr. Manson to have its habitat in the lymphatic system mainly, and the embryos to be imbibed by the mosquito, and to be discharged with the larvæ of the insect into water. The *Filaria bancroftii*, found in the subcutaneous tissues, was recognised by Cobbold as the young of the *Filaria sanguinis.* This parasite is the cause of the chyluria and nævoid elephantiasis of Egypt, Brazil, and the West Indies, hæmaturia being a frequent accompaniment or variation, the eggs passing out with the urine.

Here must also be mentioned the hæmatozoon of malaria, although much uncertainty surrounds the subject that forms a connecting link between the diseases due to hæmatozoa and those due to hæmatophyta.

Malaria is not a disease communicable from man to man through the medium of the air, but Dochmann, and also Gerhardt, have communicated the disease from man to man by inoculation and set up ague. Klebs and Crudeli found in malarial soil a fungus which set up an affection resembling malaria when inoculated into rabbits. Ziehl found similar organisms, but Cuboni and Marchiafava not only found these organisms in persons suffering from malaria, but also in those not so suffering. These observations, however, lend some weight to the idea that the malarial entity is a hæmatozoon.

Since Laveran in 1884 published the results of his

observations in his treatise on paludal fevers, in which he described pigmented, amœboid, and flagellate organisms, the discovery of similar organisms in the blood has been recorded by a number of observers. Richard confirmed Laveran's observations.[1] Marchiafava and Celli at Rome observed similar bodies in malaria.[2] Councilman and Abbot made further observations on them.[3] Golgi confirmed these results, and figured the segmentation of the amœboid bodies of malarial infection.[4] Osler, of Pennsylvania, also found them, and entered fully into the analogies of these bodies in a paper read in 1887.[5] Vandyke Carter, in India, also confirmed their presence by observation in 1887, and other observers have since recorded the presence of these protozoa in the blood of sufferers from malarious disease.

The discovery of the parasite ten years since by Laveran in ptients suffering from malarial fever thus appears confirmed by many observers; and Dr. Romanovski, of St. Petersburg, even considers that, as these parasites are invariably present, the blood of patients suffering from the disease should be examined in all cases, just as the sputum of phthisical patients, for the characteristic microbes. On the other hand, some doubt has been thrown upon these amœboid bodies as the cause of malaria, from the fact that they assume a variety of forms, which has led to the impression that they may possibly be altered blood corpuscles. But Marchiafava and Celli state that the injection of blood containing the plasmodia produces intermittent fever in man, and that the hæmoplasmodia may be recovered from the blood of the subject.

Malaria, amongst zymotic diseases, stands in a unique position. It is not directly infectious from person to person, either by contact or through the air, and no instance is recorded of malarial disease being communicated indirectly from the sick to the healthy through the medium of water, food, etc. Yet in malarious districts the disease is undoubtedly conveyed by the air, and also by water, and therefore food. What the exact contagium is remains uncer-

[1] *Comptes-rendus*, 1882. [2] *Fortschritte der Medicin*, 1885.
[3] *Amer. Journ. of Med. Sc.*, 1885.
[4] *Archiv. Sc. Mediche*, 1886. [5] *Brit. Med. Journ.*, March 12.

tain, and we have no knowledge whether it escapes from the human body or is destroyed there, or whether it undergoes a metamorphosis. It probably survives and develops in marshy water and soil, and river banks; but whether, like typhoid and cholera contagium, it may escape with the excreta, or like the *Filaria* with the urine, and contaminate water and organic fluids is not known; but the assumption hitherto held that it cannot be so transmitted makes its position unique. It is not improbable that it will be found that malaria and tropical dysentery are closely connected in their causation. Dysentery prevails wherever malarious diseases are found, and in similar frequency and intensity, and the mitigation of either disease leads to the diminution of the other.

That malaria is due to a physico-chemical miasm rather than to a vital contagium is probably destined to be disproved, as in the case of many other diseases; and it is also highly probable, as in similar cases, that further research will differentiate the malarious diseases, and reveal the fact that we have to deal with several diseases that coincide at many points but vary in their causation. Paludal fever even now possesses numerous names, according to the prominence of the prevalent symptoms, and we have ague or intermittent, quotidian, tertian, quartan, remittent, bilious remittent, blackwater, continuous, and typho-malarial fever.

Paludal diseases may be communicated by drinking water from a malarious locality, as well as by respiring the air. If the malaria contagium (*i.e.*, the dysenteric form) can survive in air, in water, in the blood-stream, and in the intestine, it is difficult to resist the impression that the contagium can be excreted, and develop in water and soil, under a proper temperature and other conditions. The typho-malarial type of disease lends force to the impression that the malarial contagium behaves similarly to the filarial and the typhoidal. The identification of the malarial organism, and the knowledge of its behaviour, will solve one of the most obscure problems of contagion.

The hæmatozoa approach more closely than the wandering entozoa to those forms of microscopic life classed as microbes, and it is difficult to dissociate them from those

bacteria and bacilli that also find their habitat in the blood-stream, or survive and travel in the blood.

The vegetable- or phyto-parasites belong to the Fungi, the achlorophyllous sub-class of the Thallophytes; these again being the stemless class of the Cryptogams, or plants that propagate by means of spores. The Fungi are divided into mould-fungi (Hyphomycetes), of which the various tinea are examples, the budding-fungi (Blastomycetes), to which the yeasts belong, and the fission fungi (Schizomycetes), which embrace the bacteria. The classifications of bacteria are numerous, including those of Cohn, Van Tieghem, De Bary and Hueppe, Winter and Rabenhorst, Zopf, and Flügge, and are all more or less provisional.[1]

They are found in various forms—*micrococci*, more or less ovoid, and occurring singly, in pairs, threes, or fours, or in chains; *bacteria*, short rods; *bacilli*, long rods; *vibriones*, curved rods, provided with flagella; *spirilla*, spiral-shaped; and *spirochætæ*, wavy and filamentous. The rate of multiplication is enormous; under favourable conditions microbes may multiply by fission every hour, and thus increase in numbers by geometrical progression. The fact that microbes double their numbers every hour would be appalling, were it not that the exhaustion of the means of nutrition, and the struggle with similar and with other species destroys them in immense numbers.

Just as the animal parasites may be considered as external, internal, and blood parasites, so it is convenient to consider the vegetable parasites as ecto-, ento-, and hæmatophyta. But our knowledge of the vegetable human parasites is as yet even more fragmentary and uncertain than that of their animal congeners, in spite of all the work that has been spent upon the subject of recent years.

Ectophytes living *free* upon the surface may be said to exist in enormous numbers; the numerous vegetable forms that may accidentally impinge upon the surface, and be equally as easily displaced, must be so regarded. Vegetable forms not possessing organs of locomotion develop a mycelium that attaches them to the surface, and thus become *stationary* ectophytes; the tinea fungi infesting the skin and hair follicles are of this kind. Grawitz has

[1] See Sims Woodhead's *Bacteria and their Products*, pp. 38-48.

attempted to show that the favus fungus (*Acherion schönleinii*), the tonsurans fungus (*Tricophyton tonsurans*), and the fungus of pityriasis versicolor (*Microsporon furfur*) are identical; it is possible, but his assumption of the identity of these with the *Oïdium lactis* is less probable.

Of ectophytes *burrowing* into the epidermal tissues, the mycetoma of the fungus foot disease of India, the fungus causing frambœsia, yaws, or *verruca peruviana*, and the growth described by Carter as causing the oriental sore or boil, with its many synonyms, are examples. Many skin eruptions and excrescences are undoubtedly contagious, such as impetigo, molluscum, and warts, and their contagion is due to bacteria and other vegetable parasites.

Entophytous organisms are found free in the stomach; such are the torulæ or yeasts, and the *Sarcinæ ventriculi* with their curious quadrate formation. Others more or less stationary are found in the walls of the digestive tract, the *Saccharomyces* (*oïdium*) *albicans* of thrush, the *Bacterium coli commune*, and the cholera bacillus; in the respiratory tract, the mycelium of diphtheria, with the bacillus in its deepest layers; in the genito-urinary tract the gonorrhœa coccus; in the deeper parts of wounds the tetanus bacillus. Other entophyta are found wandering or penetrating into the tissues and organs, the actinomyces or ray-fungus that gains access by tooth cavities, or the crypts in the mucous membranes, the tubercle bacillus which is transported in wandering cells from one part to another, the glanders bacillus that travels in the lymphatics.

Leber has also shown that the spores of the mould *Aspergillus fumigatus*, growing at the ordinary temperature of the warm-blooded animals, are capable of setting up serious inflammation in mucous and serous membranes.

The hæmatophyta, the bacteria that have been found in the blood, embrace the bacillus of anthrax, the typhoid bacillus, the bacillus of leprosy, the spirillum of relapsing fever, the micrococcus of pneumonia, and others that have not yet been fully confirmed, as influenza, measles, etc.

Besides the specific microbes, that always give rise to the same specific disease, are others—micrococci, streptococci, staphylococci—the microbes of inflammation and suppuration possessed of varying degrees of virulence. These give

rise to many different affections, or affections of different parts, accompanied by inflammation and pus formation, as ulcerative endocarditis, metastatic abscesses, etc.

It may be said that, with very few exceptions, micro-organisms have been found in the tissues or blood in almost all the infectious and contagious diseases; but in many cases they have not yet established themselves by proof as the causes of the various diseases in which they have been found. In some, more than one micro-organism has been found, and in not a few the micro-organism associated with the disease is disputed. Time and patient work alone can prove the identity of the several organisms, the *rôles* they play, and the course of their life-histories. But the undoubted establishment of the dependence upon micro-organisms of such diseases as actinomycosis, anthrax, cholera, enteric fever, leprosy, relapsing fever, tetanus, tuberculosis, glanders, and the all but established dependence upon similar causes of cerebro-spinal fever, diphtheria, gonorrhœa, ophthalmia, pneumonic fever, scarlatina, and yellow fever, and analogy in the histories of many other diseases, have founded an irrefutable pathological basis of a *contagium vivum*.

It may be fitting here to glance at the present position of pathological discovery with reference to the contagia of diseases, to briefly enumerate those diseases in which a specific microbe has been found and confirmed, those in which a microbe has been found but not confirmed, or in which more than one has been found, and those in which no true specific microbe has been discovered.

Specific microbes have been established as the cause of anthrax, in 1849 by Pollender, in 1857 by Brauell, in 1868 by Davaine; relapsing fever, 1873, by Obermeyer, Carter, etc.; actinomycosis, 1877, by Bollinger, Israel, Ponfick, etc.; thrush, by Grawitz, Cohnheim, Salomonsen, etc; ophthalmia, 1879, by Balogh and others; enteric fever, 1880, by Eberth, Gaffky, etc.; gonorrhœa, 1882, by Bockhart, etc.; glanders, 1881, by Babes and Horas; 1882, by Löffler and Schütz; tuberculosis, 1882, by Koch; pneumonic fever, 1882, by Friedländer, Weichselbaum; diphtheria, 1883, by Klebs, Löffler; cholera, 1884, by Koch; tetanus, 1884, by Nicolaier; influenza, 1891, by Pfeiffer, Kitasato, Canon, Klein; besides many other

diseases peculiar to animals, or common to animals and man.

Microbes have also been found in many other diseases, but the specific microbe has been disputed, and in some cases more than one has been claimed as specific. Cerebro-spinal fever, 1883, by Leyden, 1890, by Bonome; diarrhœa, 1888, by Klein and others; dysentery, various; erysipelas, 1880 (?), by Lukowsky, 1881, by Fehleisen; foot-and-mouth disease, by Klein; hospital gangrene, 1884, by Arloing, Chauveau; hydrophobia (?), 1882-86, by Pasteur, Fol, Babes; malarial fever, 1884, by Laveran, Marchiafava, Celli, and many others; measles, 1883, by Cornil and Babes, 1892, by Canon and Pielicke; rötheln, various; mumps, 1883, by Lingard; phagedæna, puerperal fever, pyæmia, 1870 onwards, many observers; scarlatina, 1886, by Klein; yellow fever, 1885, by Cornil and Babes; and other diseases that might be mentioned.

In chicken-pox, cow-pox, small-pox, plague, dengue, syphilis, typhus fever, typho-malarial fever, and whooping cough, no true specific micro-organism has been found, and perhaps for the same reason some of the previous class might fall more correctly into this category.

It is impossible to enter here into elaborate bacteriological details, even if it were desirable, seeing that in recent works specially devoted to the subject they are found fully discussed, and copious references are given to the extensive literature that has sprung up so rapidly. My endeavour has rather been to direct attention to the phenomenon of parasitism as a comprehensive feature of the causation of disease, which the dissociation of bacteriology from helminthology has rather tended to obscure.

As in the case of the entozoa, so also the most interesting and practical feature of the entophyta is their life-histories, inasmuch as the life-histories of parasites are the clue to the modes of their attack and to the prevention of their ravages, although the stage has not yet been reached for wide generalisations in the biology of micro-organisms.

The process of multiplication of the various classes of Fungi are still *sub judice*, but the more obvious modes of multiplication hitherto observed are broadly conveyed by their designations. The mould-fungi, or Hyphomycetes,

reproduce generally by fruit-bearing hyphæ growing upon the thread-like hyphæ of the mycelium. But spore-formation may take place in several different ways, by the development of ascospores, by acrogenous segmentation, by the formation of zygospores, or oospores, or of terminal spores. The budding, or yeast-fungi, reproduce by the budding of daughter-cells from the mother-cells, and the formation of chains or masses; endo-spore formation has been rarely observed, and also mycelial growth in these Fungi. The fission-fungi, or Schizomycetes, as already mentioned, grow in various forms; in exhausted soil they assume involution forms. Some appear only to oecur as micrococci; others have been observed to grow to threads, the threads forming spores, and bacilli developing from the spores. So that besides multiplication by fission, spore-formation also takes place in some bacteria, especially when the nutriment becomes exhausted. A further method of multiplication, besides endo-spore formation, has been observed, described as arthro-spore, or fission and spore formation, taking place simultaneously in certain micrococci.

The duration of the vitality of the spores of different organisms varies from weeks to years, but in all cases it appears to exceed immensely that of the mature state, which is limited rather to hours. It is dependent upon temperature, humidity, and soil. Whereas either drying or drowning rapidly disposes of many active microbes, they produce much less effect upon spores. The resistance of spores to destruction is considerable, especially to destruction by heat. Hence spore-bearing microbes are more tenacious of life, and yield less readily to the vicissitudes of chemical and physical influences.

The spores of anthrax bacilli require a temperature at least equal to that of the boiling point of water to destroy their vitality; applied by dry heat it requires four hours to accomplish, by steam five minutes, and by boiling water one. The sporcs of tubercle bacilli arc more difficult to kill than anthrax spores; even boiling requires to be maintained some time to kill them effectually; neither drying, nor freezing, nor putrefying media destroy them, and they retain their vitality for weeks, and possibly for months, under favourable conditions, according to the experiments of

Pasteur, and of Cadéac and Malet.[1] The spores of the *Bacillus subtilis*, or hay bacillus, are again still more resistant to destruction, and the spores of the *Bacillus mycoides* of garden earth more resistant still, but these are non-pathogenic.

Lewith found that the difference in resistance to heat displayed by vegetative forms and their spores was due to the relative amount of water contained in the albumen of the two forms ; and Cramer has found[2] that it is necessary to distinguish between the water contained in combination with the tissues, and the hygroscopic water. The spores of mould-fungi are the most hygroscopic bodies known; they contain no other water than that which they absorb hygroscopically. And consequently the fact of the resistance of their albumen to coagulation is explained by the evaporation of the hygroscopic water, the absence of water in combination, and the large amount of ash in the dry substance.

Thus the importance of spore-formation depends upon the fact that the spores are far more persistent, and more resistant to inimical influences, than the microbes from which they are derived, and this, combined with their minuteness, facilitates their diffusion, and the dissemination of the diseases to which they give rise.

[1] *Lyon Méd.*, No. 25.
[2] *Archiv. f. Hyg.*, B. xiii., H. 1, S. 71.

CHAPTER III.

DISSEMINATION.

To trace the contagia to their ultimate habitat, to ascertain the media and the organisms in which they survive and multiply, to follow the changes they undergo under varying conditions during their life-cycles, and to determine the factors that are inimical to them, will be to solve the problems of epidemiology. Such a complete solution is remote, but the first steps have been taken in all these directions, and serve as indications of the paths to be followed. One important factor, that at the very outset renders such problems of inordinate complexity, is the evolution and involution of micro-organisms. Only those microbes can grow in the bodies of warm-blooded animals whose optimum temperature coincides approximately with that of the host, but through successive generations the power of adaptability of microbes to increased or diminished temperatures is considerable. Variations in temperature, light, air-supply, and pabulum, produce such variations in the growth, development, and behaviour of organisms and their successive generations that to trace them step by step necessitates numerous, minute, and difficult researches, the results of which differ under varying conditions.

Although we are not yet in possession of facts that enable the ultimate sources of contagia to be severally and definitely stated, we know that the natural habitat of microbes is not free existence in the air. Tyndall, Miquel, and others have shown that in a still atmosphere they rapidly fall, and are deposited upon the surfaces with which they come into contact, and only by disturbance are they projected or wafted into the air. In faet, free aceess of air and light are

inimical to these low forms of life, not only from the direct physical effects, but also on account of the struggle that ensues from the contact with antagonistic organisms introduced at the same time, so that pathogenic microbes are outnumbered and outdone by saprophytic.

Of the mould-fungi, which develop wherever moisture, suitable warmth, and organic matter are present, the *aspergilli* are observed to grow on dead and living organic matter, on plants, in the bronchi of animals, and have often been found in the human sputa and bronchi. Leber observed the growth and development of *aspergillus* in the human cornea after abrasion by an ear of wheat. The ray-fungus, common to man and lower animals as the cause of the disease actinomycosis, probably leads an epiphytic existence on cereals, portions of cereal grains being frequently found in the fungus growth. The proof of this remains to be established more securely, but it is a fact of the utmost importance, inasmuch as we are acquainted with microbes communicable from lower animals to man, but not yet with any communicable from plants to man. At the International Congress of Hygiene held in London, an almost unanimous opinion was expressed that the disease is not generally communicated by transmission from cow to cow, or cow to man, or man to man, but that it is derived most probably from cereals.

Of the yeast-fungi, the *Saccharomyces albicans* (*öidium albicans*), the fungus causing thrush, would appear to be common to man and the lower animals, although experiment is deficient in this direction. Like other Fungi of this class, it probably develops and multiplies in fermentable media, although the experiments of Grawitz are not conclusive on the point.

Of the fission-fungi invariably associated with particular diseases, certain have been found to survive in spore condition, and others even to multiply, in various external media. Those associated with the septic diseases, pyæmia, septicæmia, puerperal fever, erysipelas, are derived from decaying and fermenting organic matters. Those of such diseases as anthrax, tetanus, tuberculosis, cholera, typhoid, erysipelas, have been found also in the soil. The researches of Koch revealed tubercle bacilli in the dust

contaminated by the sputa of phthisical patients, and the coma bacilli of cholera in the mud-banks of Indian water-tanks. Kitasato and others afford proofs of the presence of tetanus bacilli in the soil. These, and many other well-established experiments, have so far proved the survival of a number of pathogenic microbes in the soil.

Karlinski[1] has shown that typhoid bacilli survive for months in the soil, provided it is not thoroughly soaked through, and that then they retain their vitality only a few days, and in water a still shorter time. Roux and Yersin[2] have found that the attenuated virus of diphtheria is widely distributed, and readily regains its virulence when communicated from person to person, and grown on mucous membranes in the presence of certain streptococci; that the Klebs-Löffler bacillus may remain virulent for more than a year in the dried state outside the body, away from the influence of light and air, and that, when it is attenuated, it probably may acquire increased virulence under favourable conditions in the soil or surroundings.

The soil need not necessarily be natural soil, the artificial conditions of the dwelling affording a similar nidus. Carnelley, Haldane, and Anderson[3] have proved that the number of micro-organisms present in a dwelling-house increases with the age of the building. Observations made by Miquel upon old and new houses in Paris resulted in the same conclusion. Emmerich, of Leipzig, concluded from his experiments that the deafening material under the floor of dwelling-rooms was more highly contaminated with nitrogenous matter than any natural soil; and Miss E. Johnstone and Professor T. Carnelley, in Dundee, obtained results which proved it an all too suitable nidus for the growth of micro-organisms.

The microbes of various diseases have been found to survive in water, or the contagia have been communicated by means of water, implying their survival in that medium. Amongst these are numbered typhoid, cholera, cholera nostras, dysentery.

In food, again, especially in milk, the survival of septic

[1] *Centralbl. f. Bakteriol.*, ix. 13.
[2] *Annal. de l'instit. Pasteur*, 1889-90.
[3] *Phil. Trans.*, vol. 178, 1887.

organisms, of tubercle bacilli, of typhoid bacilli, of the contagia of scarlatina, diphtheria, and foot-and-mouth disease, is beyond dispute.

We have no example of pathogenic fission-fungi surviving on or in living plants, but it is probable that the ray fungus of actinomycosis is derived from that source. Of other forms of parasites, namely, the Helminths, many survive on vegetable forms, and Laveran's hæmatozoon of malaria may possibly be so associated.

Amongst the microbes communicable to man that survive and multiply in the lower animals, those of anthrax, tetanus, tuberculosis, foot-and-mouth disease, and actinomycosis have been isolated and traced; those of hydrophobia, cow-pox, and other diseases, still defy identification.

Of the diseases communicable from man to man, certain of them are more than suspected of being communicable to the lower animals, and it is even questionable whether such diseases as diphtheria (Löffler) and scarlatina (Klein) are not originally derived from animal sources in many instances. But the larger number are not at present known otherwise than as met with in man.

Thus, according to our present knowledge of the sources whence they more usually infect man, microbic diseases fall under the heads of anthropogenous, zoogenous, phytogenous, and saprogenous. Without necessarily restricting the origin to any one source, such a provisional allocation serves to throw into relief points of dissimilarity, which in the present revolutionary condition of ætiology is necessary in order to obtain a coherent idea of accumulating facts. The mode of entrance of organisms into the cavities, tissues, or blood, so far as at present is known, may be by inhalation, ingestion, or inoculation, according to the more commonly accepted manner of attack in each disease. Any attempt at disease classification can only be provisional, and must be modified in accordance with pathological advance.

A classification can but be derived from contemporary knowledge, and convey only an artificial idea of natural phenomena which know no hard-and-fast divisions, but imperceptibly shade off one into the other. Hence the following outline is intended merely as a sketch of the

relationships of certain of the communicable diseases and the sources from which they reach man:—

Anthropogenous.

Inhaled—
- Chicken-pox.
- Measles.
- Rötheln.
- Typhus Fever.
- Relapsing Fever.
- Influenza (? also Zoogenous).
- Whooping Cough.
- Mumps.
- Cerebro-spinal Fever.
- Pneumonic Fever.

Inhaled and Ingested—
- Scarlet Fever (? also Zoogenous).
- Diphtheria (? also Zoogenous and Saprogenous).

Inhaled and Inoculated—
- Small-pox.

Inoculated—
- Syphilis.

Anthropogenous and Zoogenous.

Inhaled, Ingested, and Inoculated—
- Tuberculosis (? also Saprogenous).

Anthropogenous and Saprogenous.

Ingested (? also Inhaled)—
- Enteric Fever.
- Asiatic Cholera.
- Cholera nostras.
- Diarrhœa.
- Dysentery.

Zoogenous and Anthropogenous.

Inoculated—
- Cow-pox (vaccinia).
- Hydrophobia (rabies).
- Glanders (farcy).
- Splenic Fever (anthrax, ? spores inhaled).
- And other diseases of animals.

Phytogenous and Zoogenous.

Inoculated—
- Actinomycosis.

Saprogenous and Anthropogenous.

Inhaled and Inoculated—
- Erysipelas.

Inoculated—
- Pyæmia (Septicæmia).
- Puerperal Fever.

Saprogenous.

Inhaled and Ingested—
Remittent Fever, Malaria (? also Phytogenous).
Ague (Intermittent Fever), do.
Inoculated—
Tetanus.
Malignant Œdema.

Such a form of classification is more or less justified by recent bacteriological researches. That many communicable diseases may be conveyed and attack in several different ways is not an indication against classing them according to the most frequent and accepted source of transmission. Neither does it imply, with regard to the class of diseases usually communicated from person to person, that the contagia cannot exist or multiply outside the human body, in lower animals, plants, or dead organic matter. Without dogmatically asserting that this tentative arrangement approaches all that is desirable, it accords with recent observations more nearly than the present divisions, and serves in some measure to indicate the mode of survival and perpetuation. It is most probable that diseases communicable from animals to man (zoogenous) by inoculation are also communicable from man to man (anthropogenous) in a similar manner, but, excepting in vaccinia, experimental inquiry is naturally precluded from proof.

The length of time the contagia survive in the various media—living and dead—must vary according to their state, whether as spores or bacteria, and the conditions under which they exist as regards temperature, moisture, and nutritive pabulum. These states and conditions are as yet understood only in fragments, which will be gathered as we proceed.

The contagia of diseases communicable to man by man, the lower animals, plants, and dead organic matter must be implied to survive a longer or shorter period in or on the sources whence they are communicated, but it does not necessarily follow that in all cases a living organism imparting the disease should be suffering from the disease. It may be immune to the contagion of which it is the conveyer, as Chauveau proved in the case of cattle-plague spread by sheep, goats, and other animals refractory to the disease,

but which nevertheless unsuspectedly conveyed the contagium. It is also well known that the coats of domestic animals may convey entozoa into the household, and most probably pathogenic microphytes. Animals in such cases must be considered to be acting as fomites.

What are fomites? *Fomes* properly signifies touchwood or tinder, and fomites include substances capable of retaining contagia. These contagia being subsequently disturbed and cast off, become the means of propagating infectious diseases. Fomites have been held to include articles of clothing, especially those consisting of wool, silk, cotton, or hair, articles of bedding and bed-clothes, articles of furniture, carpets, curtains, cushions, wall-paper, letters, towels and dressings, etc. No exact limitation has been placed upon what may be considered fomites, but it has been generally understood to include transportable substances; floors and walls of rooms are not spoken of as fomites. If contagium attaches to and survives for a longer or shorter time upon inanimate media, whether the media be transported to susceptible persons, or the persons to the media, they act nevertheless as fomites. Whether infected wool be upon a sheep's back or upon the human back, infected fur upon a cat's back or upon a rug, or infected hair upon the human head or in a wig, they may still act as fomites. By applying the term *movable fomites* to transportable materials, and regarding living organisms, that convey disease without necessarily suffering from it, as *intermediaries*, some confusion of ideas may be avoided. Fixed objects, the surfaces or interstices of which retain infection, may be regarded as *fixed fomites*.

The many different modes of conveyance of contagia, and the prevalence of one manner in one form of disease and of another in another, so that the precautions taken in the first become of little avail in the second, have rendered many incredulous of the communicability of some diseases undoubtedly possessing contagious properties. The solution of such doubts lies in tracking the diseases individually and in detail, step by step, from origin to development. Nevertheless, some generalisations may be obtained from the present recognised mode of transmission of communicable diseases.

The contagia may be conveyed to man by direct surface

contact with an infected person; this applies to the parasitic skin diseases, and to those constitutional contagious diseases that are acquired through a lesion of the surface, diseases which are communicated by inoculation, as syphilis, leprosy, tetanus, gonorrhœa, and the septic diseases. Or, by direct contact with an infected animal, most of the zoogenous diseases are conveyed by direct inoculation, as cow-pox, hydrophobia, glanders, anthrax. The indirect ways in which the contagia may be spread are manifold. They may attach themselves to fomites, movable or fixed, from which they may attack the individual through an abraded and exposed surface; or, they may be disturbed, and fall or be carried into water or food, and be swallowed; or, may be diffused in the air and be inspired; or they may be conveyed by man or animals upon the hands, as in puerperal fever, upon the sheep's back, as in anthrax, upon the proboscis of the fly, as in ophthalmia. The virus may also enter the body through the direct contamination of water or food by particles discharged from an infected individual, without the intervention of fomites. Those diseases primarily affecting the digestive tract are mainly disseminated in this manner, for example, cholera, typhoid, dysentery. In other diseases the contagia may be diffused in the air surrounding the infected individual, and be inspired by those coming within range. The eruptive infectious diseases are most readily conveyed in this manner, typhus, scarlatina, measles, and others.

Those diseases, the contagia of which are transportable by the air, are necessarily those possessing the greatest power of rapidly spreading, in the absence of isolation. The greater power therefore that a disease possesses of impregnating the air, and the greater distance the contagium can spread, the more far-reaching are the results. The contagia of some infectious diseases, especially of those peculiar to the digestive tract—cholera, enteric fever—are not readily diffused into the surrounding air; but when they gain access to large volumes of water, or food, they give rise to sudden and extensive outbursts of disease. It is held that as the cholera bacilli are killed by drying, they cannot be conveyed aerially, such a form of transport implying a dried condition, and that accidental contamination of the food by other methods

must be held accountable for the instances recorded of supposed aerial infection. This may apply in a greater or less degree to the other diseases mentioned, but yet it is an undoubted fact that young adult nurses, attending constantly on patients suffering from typhoid, rarely escape an ultimate attack of the disease. Not a few instances also have been recorded of the apparently aerial transmission of typhoid during excavations of the soil.

It must be borne in mind that the degree of humidity of the air plays an important part in the aerial transmission of contagia. Assuming that in a dry atmosphere the contagia of the diseases acquired by ingestion find an unfavourable media for survival, it does not follow that it is impossible for them to be air-borne in a humid condition. In a saturated atmosphere, or in a vapour, the humid condition may be maintained, and the gaseous density may be sufficient to support and transport the bacilli some little distance. It is well known that humid sewer gas may transport the contagium of typhoid, and probably this is one of the reasons why dysentery and yellow fever cling to low-lying lands and mouths of rivers. The writer has recorded an instance in which the evidence tended strongly to show that the contagium of typhoid was conveyed a considerable distance borne upon steam vapour. In inquiring into an outbreak of enteric fever which occurred at the Foundling Hospital at the end of 1891, it was found that the kitchen grease-trap was invaded by typhoid stools that had undergone no disinfection. The vapours from this grease-trap flowed directly into the kitchen and to the rest of the wing in which it was situated, occupied by the female children, officers, and servants, and the incidence of the disease was confined to this wing, the other wing escaping, although all partook of the same food and water. It is probable that the transmission of cholera contagion under exceptionally humid and insanitary conditions may also occasionally lead to infection, and perhaps explain the contention that the disease may be air-borne.

Although the contagia of these ingestive forms of communicable disease are only feebly and exceptionally air-borne, they possess the power of rapid and immense multiplication in water and other fluids, and become then the cause

of widespread epidemics. Not only do they appear capable of infecting limited quantities of liquids containing more or less nutritive materials, as milk and grossly polluted well-water, but also of infecting less polluted and almost unlimited quantities of water. Dr. Snow, as far back as 1848-56, showed that cholera was probably conveyed by river-water, and the water companies deriving their supplies from the Thames were the means of widely spreading the disease. More recently, Dr. Barry's report to the Local Government Board upon enteric fever in the Tees Valley during 1891 points to the conveyance of the contagion by river-water, polluted by infected sewage from towns higher up the stream.

The distance to which aerially transportable contagia may be carried with effect varies, but the difficulty of judging reliably is complicated by the power of fomites to convey them. It is consequently, in any given instance, rare to be able to verify whether any great intervening space is traversed upon the wings of the air, or upon the surface of some movable object. The contagium that has been most carefully traced the longest distance, transported by air-currents, is small-pox, but even Mr. Power's deductions, in the Sixteenth Report of the Local Government Board, tracing the incidence of the disease in zones around the Fulham Small-pox Hospital, have been doubted, and the transport by those frequenting the hospital has been held accountable for the apparently great distance traversed. But there is no doubt that the crusts of small-pox pustules convey the disease, and light particles of these could be transported to considerable distances by air-currents.

Power showed that, taking Fulham Small-pox Hospital as a centre, and dividing the surrounding district into zones of a quarter, half, three-quarters, and one mile radii from this centre, the number of houses invaded decreased the further each zone receded from the centre, and that the lines of traffic had practically no influence upon this incidence. The influence of other small-pox hospitals in London in spreading the disease has been shown by Dr. Tripe and Mr. Shirley Murphy. Confirmation is also lent to this by the fact that a marked and continuous diminution of small-pox has prevailed for the last five years in the Metropolis, since the establishment of the hospital ships for small-pox

cases down the Thames at Longreach, and the removal of all cases out of London.

But even when the exact distance that the contagium of each of the infectious diseases is capable of dissemination aerially has been ascertained, the value of such data can only be utilised to the fullest extent when complete isolation, not only of the sufferer, but of all his surroundings, is rigidly enforced, for every object coming within range is capable of carrying the contagium a still further distance. Typhus fever, oriental plague, and relapsing fever spread their contagia aerially only short distances; the former may run its course in the ward of a well-ventilated hospital, with occupied beds within a few feet of it, and spread no further; and plague-stricken patients have been treated in numbers in the open air without the medical attendants contracting the disease, provided they did not approach too closely. Military experience also records that, treated in open tents, the danger of the spread of the exanthematous diseases is reduced to small proportions. It is the closed room that increases the contagiousness, and the closely confined air that adds to the virulence, of this class of diseases.

Many patients suffering from the exanthematous infectious diseases are nursed in private dwelling-houses, and experience teaches that it is principally through the conveyance of the contagia by fomites that the disease spreads beyond the sick-room to those who do not approach it. The experience of the London Fever Hospital, extending over a period of many years, has been that, with ordinary precautions, the exanthemata do not spread beyond the precincts of the hospital, and the experience of many other fever hospitals is to the same effect.

All the inhalative anthropogenous diseases, or those diseases more or less peculiar to man, of which the contagia are air-borne, and especially of the exanthemata or eruptive febrile diseases, are capable of infecting the walls of the sick-room or ward, and the fomites, intermediaries, and human occupants therein, and these again are capable of conveying the infection further.

When a contagium has been transported from a sick to a healthy individual, directly or indirectly, it depends upon

various circumstances whether the disease consequent thereupon develops itself—(1) the particular part or organ in which the disease usually develops; (2) the infective principle reaching this part or organ; and (3) the susceptibility of the individual to infection.

Those diseases that are peculiar and limited to the skin are readily implanted, but those that attack the deeper tissues and internal organs can only penetrate this surface by means of a wound. This is the usual mode of ingress of the zoogenous and septic diseases, when acquired through the skin rather than the mucous membrane. Almost all the infectious diseases may be communicated by inoculation, but not all; the bacilli of cholera and of pneumonia, from the experiments of Wyssokowitch, do not appear to be able to reach the seat of their development, the intestinal and the pulmonary passages, even when they have gained access to the blood-stream through a lesion of the external surface. In those diseases, the seat of which is primarily in the mucous membrane, the deposition of specific virus upon the mucous surface must necessarily take place less readily than in the case of those that affect the skin, from the mere fact that the mucous surfaces are less exposed. On the other hand, these surfaces, being more protected both by their situation and rugosity, the specific infection deposited runs less chance of being swept away again, so that a longer interval for attack upon the surface is afforded. This, coupled with the lesser density and depth of the surface covering, partly accounts for the ready access that some microbes obtain to the deeper tissues and blood-stream. Minute particles of various substances may penetrate even into the alveolar cells of the lungs. It is beyond doubt that such particles may traverse the walls of the pulmonary air-cells, and also the epithelial lining of the intestinal canal, and, further, that after the absorption of such particles, they may be found in the lymphatic vessels and glands. It is also beyond doubt that, by the phenomenon of diapedesis, so fully described by Cohnheim, both white and red corpuscles of the blood may, under certain conditions, traverse with facility the coats of the vessels, and it is to be assumed that microbes may follow a similar course, although it has not yet been

shown that an equal and ready facility exists for their passage from the mucous surface to the blood-stream, and *vice versâ.*

Whether microbes can pass directly through mucous membranes into the blood has been answered in the negative, mainly through Wyssokowitch's experiments. Microbes, like other minute particles passing the intact mucous membranes, are arrested in the lymphatic glands, and have not been shown to reach the blood-stream by this course. A lesion of the surface appears to be necessary for the direct passage of micro-organisms into the blood-stream. But it must not be assumed that without a pre-existing wound of the surface microbes cannot gain admittance. The resting-place afforded to the organisms either in the mucous membrane or the lymphatics enables them probably sooner or later to so effectually attack the tissue surface, or injure it by their presence or products, as to set up a necrotic process, and to effect an entrance not only into the deeper tissues but also into the capillaries, or to diffuse their products into the blood-stream. The hyphæ of the mycelium of Fungi not only spread over the surface and grow in between the cells, but penetrate through animal membranes, and even infiltrate bony structures, and this property is probably common to all the true Fungi in varying degrees.

The ocular, nasal, and buccal mucous membranes are more exposed to infective agents than the more distant pulmonary and intestinal, and those contagia that develop in the latter must not simply be deposited, but be inhaled or swallowed, in order to reach a favourable nidus. Some contagia affect special parts or organs, and are more or less limited to them—as ophthalmia to the cornea; gonorrhœa to the urethra and the cornea; cholera and typhoid to the intestines; pneumonic fever to the lungs; and if not reaching the seat of their development produce no result. Others, again, attack various parts or organs simultaneously or successively, as diphtheria and tuberculosis. When the infective agent reaches a suitable surface it may multiply, and limit its range to a particular mucous membrane and the subjacent tissues, as in the case of ophthalmia, and gonorrhœa. Or, after primarily attacking particular mucous membranes—as of the cornea and nose in influenza; the

nose, larynx, etc., in measles; the fauces, in diphtheria and scarlet fever; the intestines, in typhoid—it may subsequently gain entrance to, or diffuse its products into, the blood-stream. From the site of the characteristic local changes, which forms the selective point of attack, it may extend its effects to the nervous or circulatory systems, or to the various internal organs, giving rise to the specific constitutional changes of the disease. That it is not necessary for all organisms to enter the blood-stream, to produce characteristic constitutional effects, follows from the fact that, whereas the bacilli of typhoid and the spirilla of relapsing fever have been found in the blood, the bacilli of cholera and the micrococci of pneumonia have not. Roux and Yersin have shown that the Klebs-Löffler bacillus in diphtheria gives rise to the characteristic symptoms of the disease by diffusing its products into the blood, whilst the bacillus remains situated in the mucous membrane. Similarly, in tetanus, it has been shown that the organism remains in the wound to which it has obtained access, and produces the specific nervous symptoms by diffusion of its products.

The most characteristic diseases that specially require a pre-existing lesion of the surface for the ingress of the contagia are—

Pyæmia and Septicæmia.	Rabies.
Puerperal fever.	Tetanus.
Syphilis.	Glanders.
Leprosy.	Vaccinia.

But the power of penetration must be admitted to be possessed by the infective agents of those diseases that are not known to require a pre-existing lesion, although discontinuity of the surface probably hastens ingress and develops the attack more rapidly. How far the variation in the duration of the latent and invasion stages of these diseases is due to the facility or difficulty of ingress of the contagia is not known. Probably it is the main factor that determines the abnormally abbreviated or prolonged period of these stages in certain cases.

Another factor is the quantity of virus entering. It was formerly believed that, regardless of quantity, the power of

a virus was illimitable. It is now known that the virulence of the contagium may vary enormously, and that whereas the minutest quantity of an extremely intensified virus may produce rapid and fatal effects, a comparatively large quantity of a very attenuated virus may only result in a delayed and feeble reaction. In fact, dosage is a factor to be reckoned with as well as pathogenic power.

Another mode of ingress remains to be mentioned. Various eruptive fevers and blood diseases from which a mother may suffer can be communicated to a fœtus in the womb. It would appear that it is possible for a disease to reach the fœtus through the mother, the mother being insusceptible and remaining immune, as in the case of a healthy mother giving birth to a child covered with small-pox eruption. Mr. Alfred Lingard endeavoured to ascertain by experiment with anthrax bacilli "the influence, if any, exerted by the fœtus on the mother, when the fœtus becomes the subject of an infectious disease contracted independently of the mother," and he found that "in those cases where the fœtus alone is inoculated, the mother remains freed from the bacillary disease, and at a later date is found to have acquired immunity."[1] Birch-Hirschfeld and Schmorl have definitely proved that in the human subject tubercle bacilli may pass from the mother to the fœtus,[2] establishing that which has long been assumed—namely, that the hæmatophyta may traverse the placental vessels.

From the moment of exposure to a contagium till the appearance of the characteristic symptoms of the resultant disease a variable period elapses, known as the incubation period.[3] That the latent stage should be of more variable duration than the succeeding stages of a disease may be gathered from the preceding description of the varying modes and points of ingress of the contagia, and the vicissitudes they may undergo before entering the system, which not only differ in each disease but also in each

[1] *Proc. Roy. Soc.*, 1888. [2] *Beitrage z. Path. Anat.*, etc., 1891.

[3] Unfortunately, the incubation stage is limited by some observers to the period elapsing between exposure and the onset of premonitory symptoms, and by others extended beyond the first sickening to the point when the rash, or other specific sign, exhibits itself. As these two stages vary in different diseases, it is desirable to consider the first as the *latent* period, and the second as the period of *invasion*.

particular case. For instance, those diseases that may be acquired by infection, when inoculated differ in the duration of their stages under the two conditions, probably differing most in the latent stage. It is stated that, from exposure to eruption, the period of fourteen days that elapses in small-pox after infection, is after inoculation reduced to seven or eight days; in measles the twelve or fourteen days is reduced also to seven or eight days. It has also been stated that in scarlatina the incubation stages after natural infection remain after artificial inoculation of about the same duration, and in plague the two to five days become definitely four days. A knowledge of the variations in the duration of the latent stage of the several diseases when communicated by infection and by inoculation would be valuable as affording some insight into the length of time occupied by contagia in penetrating from without into the blood-stream or special organs, but we are deficient in these comparative observations.

It is obvious that the latent is more variable in duration than the invasion stage, and in fact than any of the other stages of a disease. But, apart from the variability in the length of time the specific virus may occupy in penetrating or diffusing into the system, there is the superadded difficulty of fixing the exact date of the various phenomena that mark the several stages.

It is only rarely that the exact date of *exposure* can be fixed by some special circumstance, and by the elimination of all others. The first premonitory symptoms that fix the date of *invasion* vary considerably, both in order of appearance and in intensity. The rise of the clinical thermometer would mark more accurately than any other sign the onset of constitutional symptoms, but the opportunity of observations of temperature immediately before or at the moment of invasion is rarely available. The characteristic signs that mark the *maturity* of each disease may be more or less pronounced. In the progress of the disease the *decline* may be retarded or accelerated, and the *termination* materially influenced by complications arising from changes in the function or the structure of various organs. And finally, when with convalescence the contagium has been eliminated from the system, the period at which *freedom from infection*

is reached can only be judged by loss of the power of infecting others.

The exact date of ingress of certain inoculated diseases may be known and fixed, and the local changes that precede the constitutional symptoms may be apparent upon the surface, and be observed and noted, as in

Diseases Inoculated.	Local Signs.	Constitutional Symptoms.
Small-pox, after inoculation	2nd day	8th day
Vaccinia, after vaccination	2nd to 3rd day	slight, 5th to 10th day
Syphilis, after specific contact	3rd to 4th week	5th to 6th week
Rabies, after bite	absent	2, 6, 12 weeks, or longer

In other diseases the date of ingress cannot be so precisely fixed. The local changes at the point of ingress are unmarked, or take place in a situation beyond observation, as in the intestines in typhoid, and the period of latency is generally completed by marked constitutional invasion, accompanied in some cases by severe localised changes, as in the throat in diphtheria and scarlatina. The usually observed duration of the latent period in a number of diseases is recorded in the following table, compiled from various sources:—

Latent Period of Certain Diseases, or the Interval from Specific Exposure to Sickening or Invasion.

	Minimum.	Average.	Maximum.
Small-pox	11 days	12 days	13 days
Chicken-pox	10 ,,	13 ,,	19 ,,
Measles	4 ,,	8 ,,	12 ,,
Rötheln	10 ,,	14 ,,	17 ,,
Scarlet Fever	1 ,,	3 ,,	8 ,,
Typhoid Fever	5 ,,	11 ,,	21 ,,
Typhus Fever	4 ,,	7 ,,	10 ,,
Dengue	4 ,,	5 ,,	7 ,,
Diphtheria	1 ,,	3 ,,	8 ,,
Mumps...	7 ,,	14 ,,	21 ,,
Whooping Cough	4 ,,	8 ,,	14 ,,
Influenza	hours	1 ,,	days
Plague	2 days	5 ,,	8 days
Yellow Fever	1 ,,	—	weeks
Cholera	hours	3 days	5 days
Relapsing Fever	2 days	5 ,,	12 ,,

A fact that adds to the difficulty of exactly fixing the latent stage is the insidious manner in which the constitutional invasion gradually takes place in some diseases, so that the transition from health to sickness occupies not a few hours but days, and even weeks. For instance, the latent stage of enteric fever may vary from a few days to three weeks (Broadbent); it is generally beyond ten days (Roberts).

The invasion stage presents equal difficulties in definition. In some diseases the sickening coincides with the gradual onset of the characteristic symptoms, and there is little or no distinct invasive stage: as in cholera, characterised by the diarrhœa and vomit; influenza, by the catarrhal fever; relapsing fever, by symptoms liable to variations and relapses; yellow fever also by symptoms liable to great variation, which may take from two to six days to pronounce themselves, but even the jaundice and black vomit may occur at any period of the disease. In plague, again, buboes may actually appear from the second to the fourth day. In dengue a primary rash may occur on the first, and a second subsequently appear, and several relapses may take place. So that in certain diseases the characteristics are gathered from a number of symptoms which may appear in such irregular order as to prevent fixing the true period of onset.

Mumps, whooping cough, and diphtheria present no true rash, and are specially characterised in typical cases, respectively, by the parotid enlargement, the crowing whoop, and the diphtheritic membrane, the interval from the sickening to their appearance being in

	Minimum. Days.	Average. Days.	Maximum. Days.
Mumps	No interval.	½	1
Diphtheria	,,	1	3
Whooping Cough ...	8	10	14

The invasion stage, or interval that may elapse between the sickening and the development of the rash in the eruptive fevers, varies in the following manner:—

	Minimum. Days.	Average. Days.	Maximum. Days.
Small-pox	1	2	3
Chicken-pox	No interval.	½	1
Measles	3	4	6
Scarlatina	No interval.	1	2
Rötheln	,,	½	1
Typhus	3	4	5
Typhoid	4	10	21

It is very important that some practical idea should be formed of the period of time required for the observation of an individual after exposure to any given infection, or, in other words, the length of time during which he will remain "suspect." The periods recorded by different observers vary immensely, but general consensus of opinion appears to regard the following as reasonable intervals, after the expiration of which the probability of developing the diseases mentioned is remote:—

INTERVAL FROM EXPOSURE TO CHARACTERISTIC SIGN.

	Minimum. Days.	Average. Days.	Maximum. Days.
Influenza	1	2	4
Diphtheria	1	3	8
Asiatic Cholera	1	3	5
Yellow Fever	1	4	6
Oriental Plague	2	4	8
Scarlatina	2	5	8
Relapsing Fever	2	5	12
Typhus Fever	7	10	15
Rötheln	10	14	17
Measles	10	14	18
Chicken-pox	10	14	18
Small-pox	13	14	15
Typhoid Fever	10	14	20
Mumps	7	14	21
Whooping Cough	7	14	21

It is extremely difficult to fix the time at which a person attacked by either of these diseases commences to be infectious to others, and no systematic attempt appears

to have been made to ascertain this particular period. It has been generally assumed that in the endemic eruptive fevers the elimination of infection does not commence until the febrile symptoms are well pronounced, or the rash appears. Measles is an exception, and is undoubtedly infectious from the earliest catarrhal symptoms, probably through the buccal and nasal mucus.

Nevertheless, it is customary to reckon the duration of infectiousness from the first symptoms of invasion to the period of completion of desquamation or desiccation of the eruption, or the cessation of characteristic signs in non-eruptive diseases, and the establishment of convalescence. This is usually held to be from 6 to 8 weeks in whooping cough, scarlatina, and diphtheria; from 4 to 8 weeks in typhoid fever; from 3 to 4 weeks in typhus, measles, and small-pox; from 2 to 4 weeks in mumps and rötheln; and 2 weeks in chicken-pox. But Löffler has shown that the diphtheria bacillus may remain about the mouth and fauces in a more or less virulent form for much longer periods, and the recurrence or recrudescence of this disease, as well as of scarlatina, and the spread after convalescence, may be due to this fact.

Neither mycosis or mechanical action, nor the consumption of nutrient materials of the host, will alone account for the pathological effects of microbes. Micro-organisms, in common with all living organisms, induce chemical changes, and these chemical changes impart a septic or toxic character to the symptoms of infectious diseases. The products of micro-organisms, and the effects of these products upon the host, are equally as important as the determination of the presence of the organisms themselves in the causation of infectious diseases. These metabolic products act not only upon the host invaded, but react upon the microbe that produces them, and also upon other microbes. They are either enzymes (chemical ferments) secreted by ferment bacteria, such as the butyric, and so called to distinguish them from the organised living ferments, such as the torulæ, the active principles of which are not known apart from the presence of the living organisms; or sepsines, ptomaines, or toxines, the basic compounds formed in the decomposition of proteids by

both putrefactive and specific bacteria. The action of these metabolic products upon the microbes themselves is seen in the effects of alcohol stopping the growth of yeast, and in the involution forms assumed by many microbes in pure cultivations. The action upon other microbes exhibits itself in the inimical or antiseptic action of alcohol, acetic, lactic, and butyric acids, and in the opposite effect by which some microbes appear to pave the way for others, as the streptococci found coincidently with diphtheria bacilli; and in this connection Klein records some interesting effects of concurrent inoculations of different infections in the same animal body, in the Reports of the Medical Officer of the Local Government Board, 1889 and 1890.

Bacterial products have been held to alone account for the effects of pathogenic microbes upon the system, the poisoning of wounds and of food, and also for the production of immunity and susceptibility. But a typical infectious disease has not yet been reproduced in its entirety by bacterial products alone, although Roux and Yersin have nearly approached this result, producing all the symptoms of diphtheria with the exception of the false membrane and the power of reproducing infection.

This power of reproducing infection necessitates the presence of the specific organism, and the access of the organism to the soil or part specially suitable for its growth and multiplication. It is this "growth and multiplication" that marks the local characteristics of the disease more especially, and the constitutional manifestations are due mainly to the toxic influences of the products of the organism.

Apart from their causation, the communicable diseases have been clinically classified according to the system particularly affected in each case, as the *eruptive* (cutaneous system), small-pox, measles, scarlatina, typhus; the *septicæmic* (circulatory system), erysipelas, septicæmia, pyæmia, puerperal fever; the *neurotic* (nervous system), rabies, tetanus, diphtheria, whooping cough, influenza; the *intestinal* (digestive system), cholera, dysentery, diarrhœa, enteric fever; the *pulmonary* (respiratory system), pneumonic fever; the *lymphatic* (lymphatic system), tuberculosis, syphilis, leprosy.

The several stages of the communicable diseases correspond with the different periods of the life-histories of the contagia within the body. Of the changes these undergo, and of the share taken by their products in the causation of symptoms, our knowledge is but slight. During the course of these diseases, or after their subsidence and during convalescence, the contagia are given off from the surface or the cavities of the body, and eliminated from the system. The mode of exit, and the parts from which they thus derive, have been gathered from clinical experiences, many of which have been confirmed by more recent experimental researches.

They may be eliminated from the body in the exhalations, secretions, excretions, eruptions, or discharges. It is well-nigh impossible to restrict the elimination of any disease rigidly to one particular part or process, as the main experience upon which we rely is the usual period at which, and the manner in which, infection is generally found to be communicated. The contagia of the septic diseases, pyæmia, septicæmia, erysipelas, phagedæna, hospital gangrene, puerperal fever, may be communicated by discharges from wounded surfaces; similarly actinomycosis, anthrax, glanders, syphilis, and possibly leprosy, are conveyable. Gonorrhœa and ophthalmia are conveyed by the urethral and ocular discharges; the contagia of cholera, diarrhœa, dysentery, and enteric fever, and probably also of yellow fever, are contained in the alvine evacuations. The *Filariæ* of endemic hæmaturia and chyluria are found in the urine.

The microbes of pneumonic fever and pulmonary tuberculosis are found in the sputa, and those of diphtheria and thrush in the buccal secretions. It is also known that the saliva in rabies or hydrophobia contains the contagium of the disease. Both the nasal and buccal secretions are capable of conveying the specific virus of measles, influenza, diphtheria, and probably many of the exanthematous diseases, as well as mumps and whooping cough. All the exanthemata may be communicated by the cast-off particles of the eruptions, excepting perhaps typhus and enteric fever. The number of diseases that are generally assumed to be communicable by the exhalations is considerable, including all the exanthemata (excepting typhoid) and whooping cough,

mumps, relapsing fever, influenza, febricula, dengue, plague, cerebro-spinal fever, and others.

As experimental research progresses we shall be able to define more precisely the manner in which the contagia are emitted, and the effects of exhalations will be reduced to less vague proportions. Diseases capable of attacking different parts and organs must necessarily vary in their infectiveness according to the situation of the contagium. Tuberculosis of the lungs is proved to be readily communicable; but when the joints and peritoneum are attacked the chances of communicability are remote, if possible. The same applies in a corresponding manner to leprosy. This serves to explain, in a measure, the opposite opinions hitherto held as to the communicable character of these diseases, and applies in varying degrees to others.

After egress from the body, the distance that a contagium may spread will depend upon whether it is borne by air, water, food, fomites, or intermediaries; upon its capacity for survival outside the body; and upon the soil, nutrient material, or living organism ultimately reached before loss of vitality, or destruction. The dissemination of the contagia is comparable in this respect to the scattering of the seeds of plants, which are capable of being carried by various means to great distances, some springing up almost everywhere, others flourishing only in a few spots, others again failing to find suitable soil. The differentiation of diseases caused by living contagia from those due to other causes brings into more prominence the distinctive manner of their dissemination.

The members of a community exposed to the same meteorological conditions will exhibit similar types of diseases, varying directly with those conditions. An increase in the ordinary respiratory diseases takes place coincidently with a fall in the temperature below a certain degree; an increased number of individuals will suffer from bronchitis, or some other form of pulmonary complaint, as the temperature of the air lowers, and the effect will be more or less simultaneous throughout the community. No centrifugal extension will be observable. On the other hand, when, little influenced immediately by meteorological conditions, a disease is observed to spread .centrifugally, and attack

individuals, or groups of individuals, not simultaneously but consecutively, the inference is that it is due to a contagium passing from one to the other. The longer the interval between exposure and attack the more perceptible does this consecutiveness become; the shorter the interval the more it approaches to the appearance of simultaneity. This applies when the disease is contracted by others aerially and directly from an infected individual; but indirect aerial infection, as through fomites, frequently baffles us in tracking it to its source, although when large numbers are affected this centrifugal dissemination becomes very apparent, provided only that we possess exact knowledge of those attacked. When the disease is contracted by a large number of individuals indirectly through the medium of water or food, simultaneity is again the effect mainly produced. The difficulty of establishing contagiousness is also increased by the varying susceptibility of individuals, many escaping, so that, in order to establish it, it is necessary to prove: negatively, that those who had no contact with the suspected person, air, or fomites, or who did not ingest the suspected water or food, did not contract the disease; and affirmatively, that *some* of those who did come into such contact, or did so ingest, contracted the disease.

It is not a matter of hesitation in watching the gradual progress of a disease from individuals to families and households, from one house to another, from village to village, and town to town, to say that such a disease is communicable. This difficulty arises when the progress is either extremely rapid, producing the appearance of simultaneity, or extremely slow, whereby the consecutiveness is lost. Two diseases, usually spreading aerially, exhibit these extremes in a marked degree, influenza and phthisis, and in both contagiousness has been denied, but careful investigation has placed it beyond doubt. The slow development of leprosy, and the loss of consecutive effect, has also led to the denial of its communicability.

It is observed that the great characteristic of the acute communicable diseases is that they spread from a centre in an ever-increasing circle, and that every case in the circle tends to become a new centre, as the fairy circles and rings of the meadows spread centrifugally, from the effects of

Fungi upon the grassy surface. Secondary centres are formed, either breaking up the primary circle by extension in particular directions, or obliterating it by a number of smaller circles coalescing and involving an extended and irregular area. Further, every case removed from the circle and transported to a distance becomes a fresh centre, and starts the process anew, so that successive outbreaks occur in localities in communication.

This characteristic may be utilised, by an artificial reversal of the process, in order to trace an epidemic to its source. If all the persons attacked, and their situation and social circumstances, be known, a centripetal analysis will lead to a central focus. By plotting on a map of the locality the positions of all the sufferers, they will be found to surround the focal source in a more or less regular circle. This is a valuable method of tracking disease, when circumstances render it applicable. One great fallacy must be guarded against. If all the cases occurring during a considerable interval of time be plotted on the same map and in the same colour, the effect produced will be mere general dissemination, according to density of houses and of population. To avoid this as much as possible a series of maps must be constructed, and each map should be so plotted as to show only those cases attacked during a short and definite period, the interval depending upon the form of disease.

Briefly, the facts that point to a disease being communicable by air-borne infection, as recently illustrated by influenza, are—

1. The first case, if traceable, is often a new arrival, and possibly from an infected locality.

2. Sporadic or sparsely scattered cases always precede a general epidemic.

3. The extension of the disease follows the lines of human intercourse.

4. In widely-spread epidemics, and in pandemics, the large towns are first infected, then the smaller towns, the villages, and finally the remote rural districts.

5. In private houses, the persons most in contact with the outside world are generally first infected, those more closely confined later.

6. In public institutions, generally the chief officers and those most in contact with strangers are first attacked, the minor officers and subordinates later, and the inmates last.

7. Inmates of closely-guarded and isolated institutions, as prisons, asylums, and convents, often escape entirely.

The number of those attacked during an epidemic increases until a maximum is reached, and then declines. The rapidity of the extension of the disease is in direct proportion to—

1. The brevity of the incubation stage of the disease.
2. The length of time during which it is infectious.
3. The distance the infection may travel or be carried.
4. The absence of isolation and disinfection.
5. The susceptibility of the individuals exposed to infection.

Isolated cases of an infectious disease, whether endemic or exotic, are spoken of as sporadic; when these multiply within given areas they become epidemic; and still extending over larger areas, from one country to another, they become pandemic. The progress of pandemics is marked by a wave-like character, the number of individuals attacked gradually rising as the wave proceeds, and falling as it recedes. This is best exemplified in exotic diseases, as cholera, but endemic diseases are subject to the same epidemic and pandemic waves.

Dr. Guy recognised three varieties of this class of disease, which, according to their habitat, he named exotic, indigenous, and naturalised, the two latter being subdivisions of the endemic. Sporadic, adventitious, or sparse cases of either variety may be imported, or may occur at almost any time and place, but extension depends upon various circumstances. If the disease be exotic and capable of temporary or permanent naturalisation, or if it be indigenous and circumstances are favourable, it may become epidemic, and its extension to other countries may reach pandemic proportions; and, reversely, an exotic pandemic in subsiding may become permanently naturalised, and remain locally indigenous. The terms endo- and exo-epidemic, also used to define the derivation of disease outbreaks, are self-explanatory.

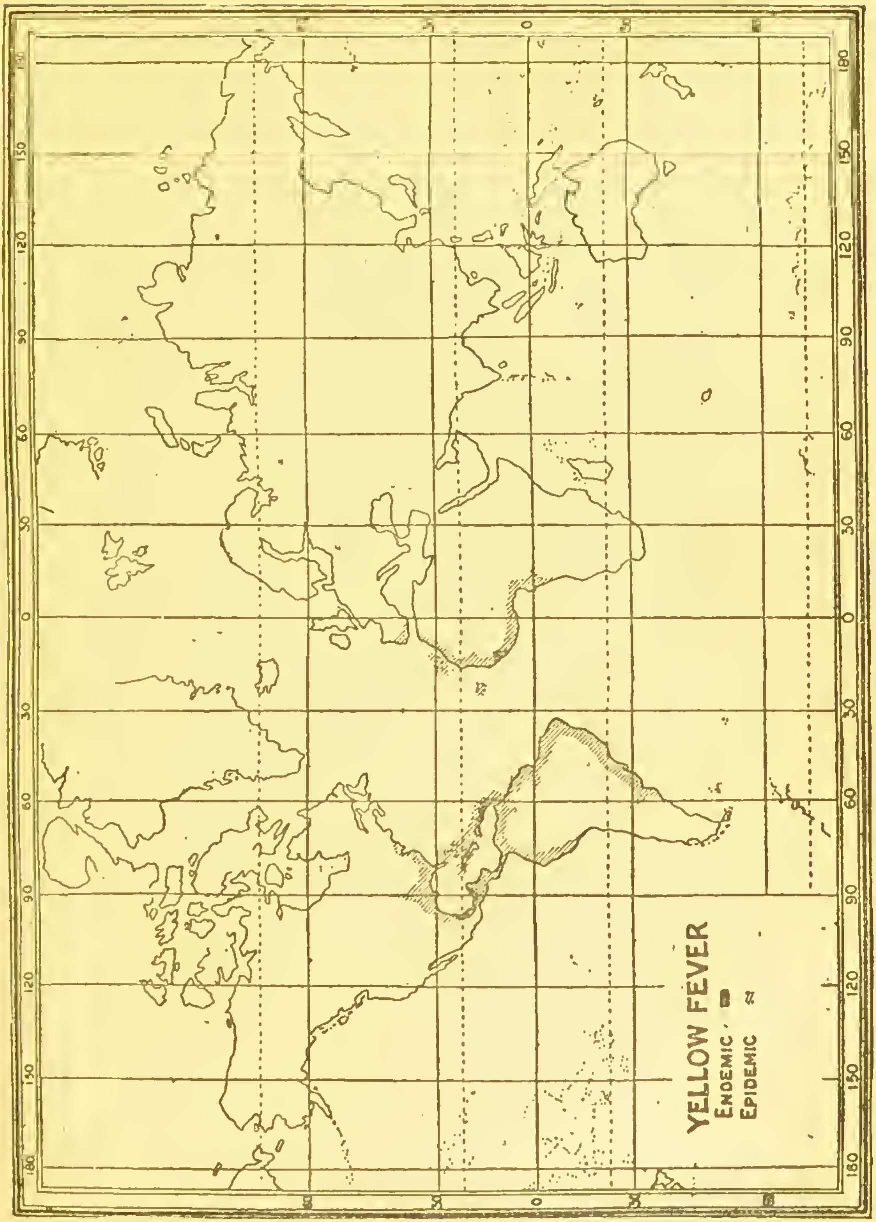
Most of the microphytic diseases are found to prevail

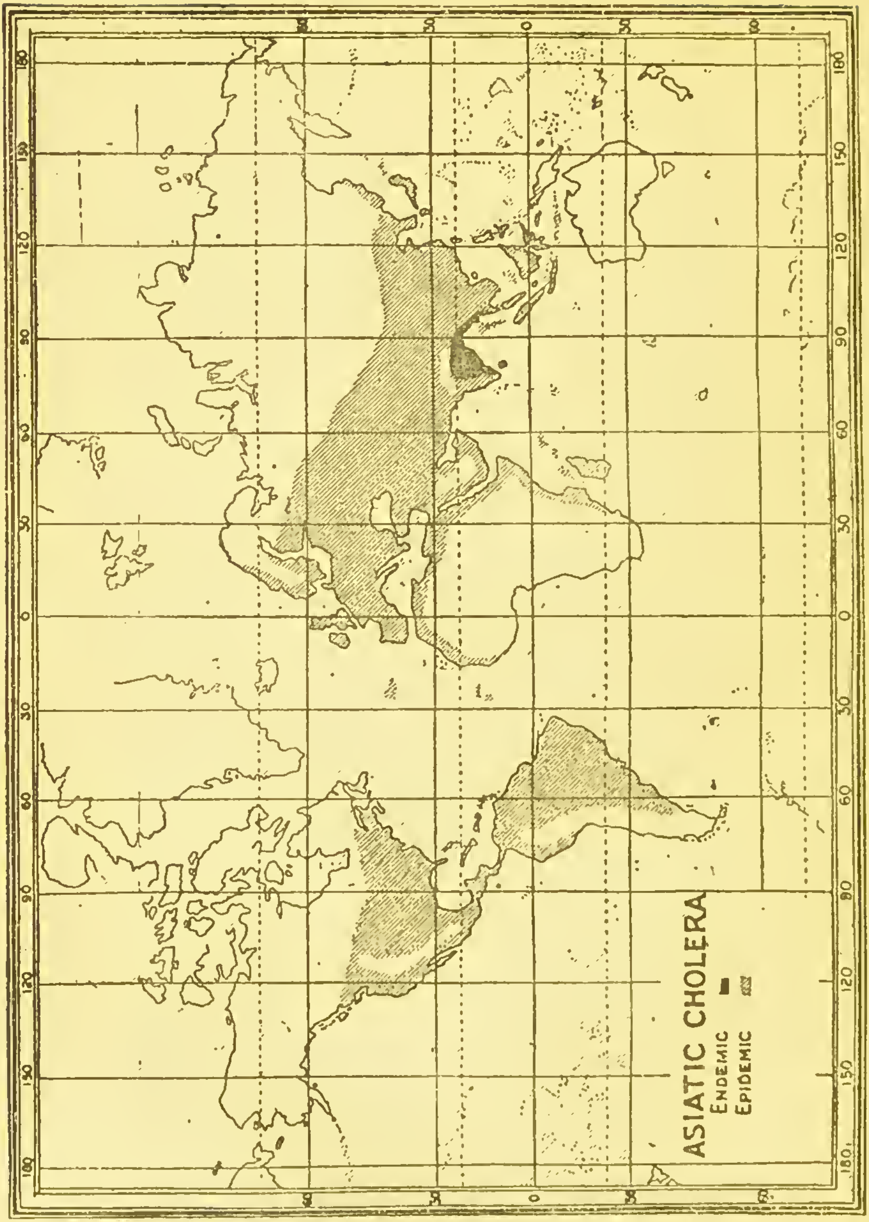
more or less in all parts of the civilised world. Certain are more prevalent in temperate zones, others more frequent in tropical zones, whilst a few are almost peculiar to the tropics, and are exotic in relation to this country. Amongst diseases indigenous to certain tropical areas, but not naturalised in this country, may be specially mentioned Oriental plague, Asiatic cholera, yellow fever, dengue, yaws, elephantiasis, endemic hæmaturia and chyluria, Oriental sore, and madura foot. In addition to these, some diseases, such as malaria and dysentery, appear in a more severe form in tropical than in temperate zones. On the other hand, scarlatina, erysipelas, whooping cough, cerebro-spinal fever, and what is known as cholera nostras, are more common in temperate zones.

Of tropical, or exotic, diseases three are especially subject to epidemic extensions—yellow fever, plague, and cholera. But, whereas plague and cholera are, under favourable conditions, temporarily naturalisable in this country, yellow ever appears to be a non-naturalisable exotic.

The indigenous or endemic areas of yellow fever are mainly the Gulf of Mexico, the West Indian Islands, and the Guinea coast. The limits of epidemic extension in the Western Hemisphere are 34°54 south latitude (Monte Video), and 43°4 north (Portsmouth, New Hampshire), and in the Eastern Hemisphere 8°48 south latitude (Ascension), and 43°34 north (Leghorn), being mainly confined within the isothermal lines of 60° F. The disease seldom extends inland beyond the humid area of the sea-coast and of the shores of navigable rivers, and rages almost exclusively on the plains, rarely spreading to any considerable elevation, and only when the temperature is favourable. It is almost exclusively a disease of towns, and especially of the filthy and crowded quarters of seaports (Hirsch). It requires a temperature of at least 70° F. for its origin and spread; cold weather, heavy rains, and severe droughts check its progress, and frost rapidly terminates an epidemic.

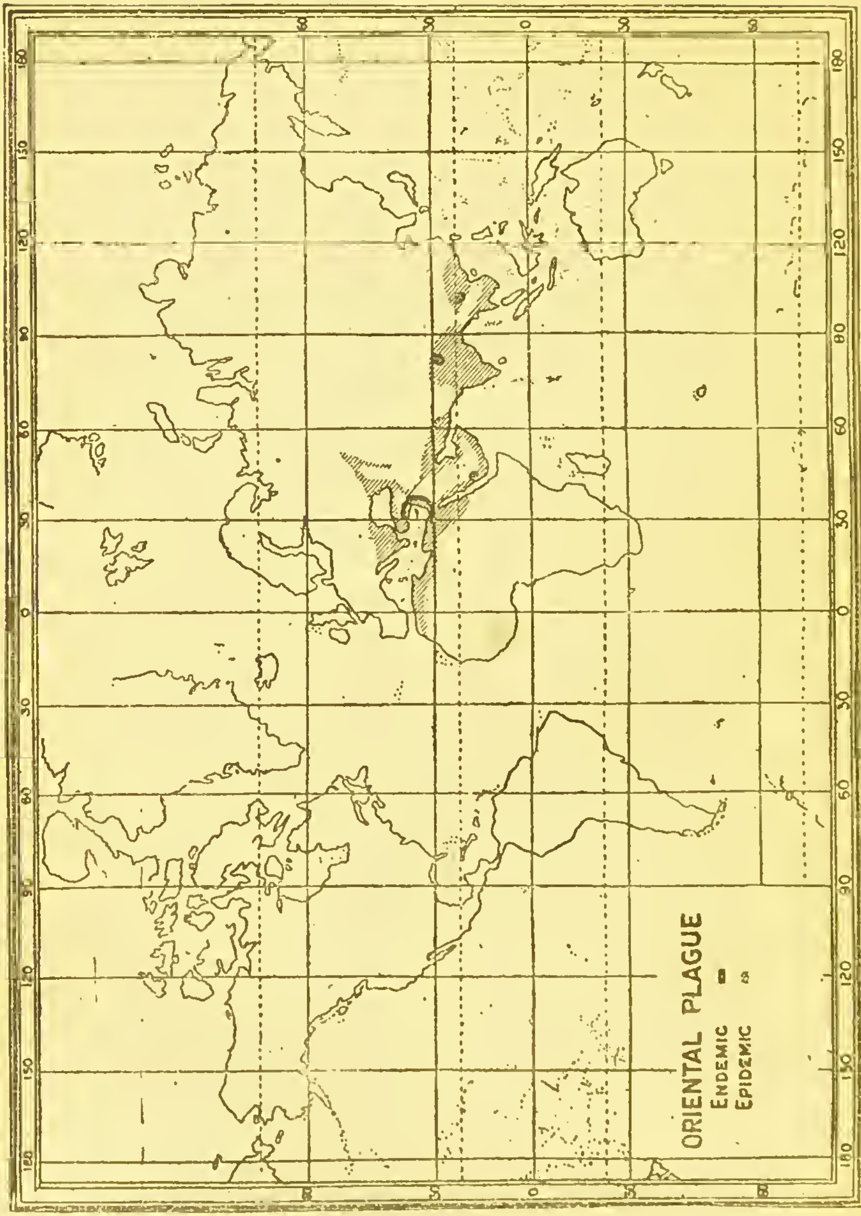
Cholera, on the other hand, is an exotic disease capable, under favourable conditions, of temporary naturalisation and of pandemic extension over the greater part of the habitable globe. Certain countries situated to the extreme north or to the extreme south, and certain less accessible

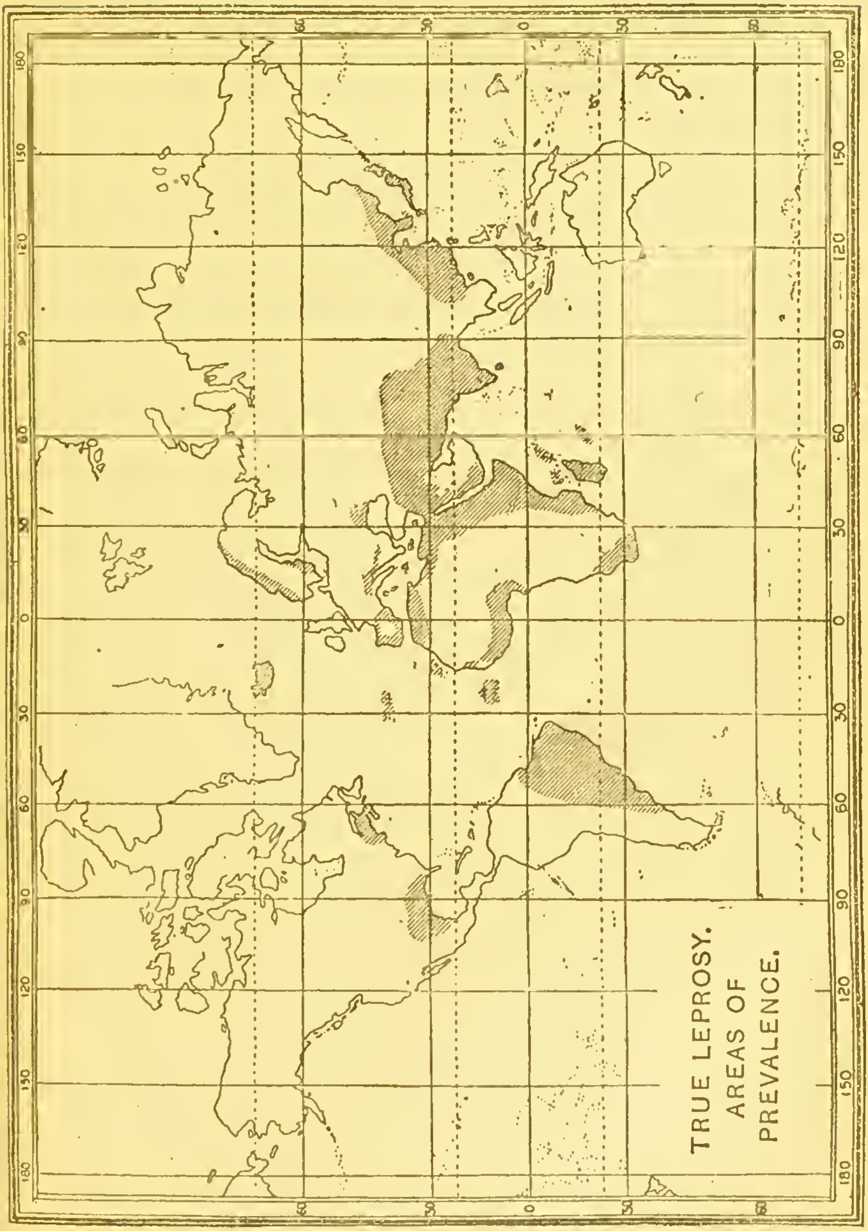

YELLOW FEVER
ENDEMIC
EPIDEMIC


ASIATIC CHOLERA
Endemic
Epidemic

islands have escaped hitherto: Australia and the Pacific Islands, the west coast and southern end of Africa, the west coast and southern end of South America, the territories north of the fiftieth parallel in North America, the northern islands and territory of Europe, Siberia and Kamtschatka in Asia. The effect of elevation is expressed in the law deduced by Farr, that the proportion of deaths from cholera among the inhabitants is inversely to the elevation of a locality. Although the pandemic extension of cholera is so wide, the area of more frequent epidemics is confined to India, Southern Asia, and the coasts of the Red Sea, especially the Hadjez infected by the Indian pilgrims to Mecca; the true endemic or indigenous habitat being the Bay of Bengal, and particularly the delta of the Ganges. The contagium of cholera appears capable of acclimatising itself under nearly all conditions of locality and climate, lying dormant during the winter months, and extending as the warmth of summer returns. Increased temperature and humidity increase the virulence of the contagion, which is spread not so rapidly by general insanitary conditions as by the pollution of water supplies.

Oriental plague was equally capable of wide extension under the unhealthy conditions prevailing in the Middle Ages, but it has been driven back to much narrower limits at the present day. Its endemic area is doubtful, but centres of infection have appeared in the Levant, Asia Minor, Syria, and Egypt, in the province of Assir, north Yemen, situated south of Mecca, in Arabia, in the province of Yunnan, in China, and in the mountainous districts north of Hindoostan. Its epidemic area has extended to the southern provinces of China, and to Siam, various parts of India, Persia, the coasts of Arabia, the northern coast of Africa, European as well as Asiatic Turkey, and parts of Southern Russia, Astrakan, and the Caucasus. Although plague has a preference for marshy and alluvial soils, with a warm, humid atmosphere, it freely extends to high lands, and appears to be most tenacious of ill-ventilated and crowded houses, and neighbourhoods with absence of scavenging and cleanliness, and has been known as the plague of the poor and of poverty. Seasonal changes have produced very variable results in different


ORIENTAL PLAGUE
Endemic
Epidemic


TRUE LEPROSY.
AREAS OF
PREVALENCE.

countries, due probably to varying effects upon the habits of the population. Whatever tends to bring persons more frequently and nearly together must tend to spread the disease, which closely resembles typhus in its mode of communicability.

Like plague, leprosy is being driven back, at least from Europe, although it widely prevails in various parts of the world. It is a disease that appears capable of universal naturalisation, but, not being an acute infectious disease like the three already mentioned, its progress is slow, and by the absence of epidemicity the area of its prevalence becomes its endemic area.

CHAPTER IV.

MODIFICATIONS.

THE fatality of communicable diseases is so variable that the relative positions they occupy as destroyers of life, at any particular time and place, may be very different from that which they may have previously occupied, or that they may reach at a future period. The fatality of a disease is most accurately judged by the proportion of deaths to the number of individuals attacked—that is, by the case-fatality. No complete figures are yet available on a large scale presenting case-mortalities of infectious diseases for whole populations. Hospital statistics, although thoroughly reliable as far as they go, are open to certain variations from true case-fatalities, by reason of the amount of selection that must take place in the cases seeking admission. Or the mortality may be judged by the number of deaths in proportion to the population. This form of mortality introduces the effect of prevalence, so that the mortality of a highly infectious disease attacking a large number, and having a low case-fatality, may appear higher than that of a less prevalent infectious disease with a high case-fatality. Nevertheless, the number of lives destroyed in a population by a given disease, directly or indirectly, regardless of its infectivity, must be the ultimate criterion of its fatality, whether the prevalence be endemic or epidemic.

The many factors influencing the rise and decline of epidemics render their study extremely complex, but the reason why at one period their infectiousness, or their destructiveness, are greater or less than at another will doubtless ultimately be analysable from the resultant effects, into the several natural phenomena acting simultaneously or successively. As they have their periods of extension or retraction of

areas of prevalence, so within these areas they have their periods of increased or diminished virulence, and some of the causes that lead to these results are capable of estimation.

In proportion to population, the mortality from diseases transmitted by inoculation from animals—as anthrax, rabies, glanders, actinomycosis—is small, because the number attacked is small, but the fatality of those attacked is great. Other diseases communicated through lesions of the surface and inoculations, when chronic—as syphilis, leprosy, and tuberculosis—are liable to periods of dormancy and activity, and are very variable in their duration and fatality. When more acute—as tetanus, puerperal fever, septicæmia, pyæmia, erysipelas—a fatal issue is more rapid, and more frequent. The general case-mortality of the last-mentioned has been estimated at from 3 to 11 per cent. only, but the other diseases have a far higher fatality.

The mortality of pandemic diseases that run an acute course and spread rapidly is extremely high during the epidemic period in the case of plague, cholera, and yellow fever, but very low in influenza. Plague has been variously estimated to kill from 39 to 95 per cent. of those attacked, cholera from 20 to 80, and yellow fever from 10 to 70; whereas influenza scarcely kills at the highest estimate more than 3 or 4 per cent. of those attacked, and more probably on an average under one-half or one-quarter even of this estimate. Oriental plague, Asiatic cholera, and epidemic influenza, as exotic diseases, find almost their indigenous counterparts in diseases closely resembling them—namely, typhus, choleraic diarrhœa, and contagious catarrh; but these latter diseases are of a less fatal type, and the last may be said to be benign.

Certain mild diseases must be mentioned in contrasting the destructive effects upon life. The mortality of chicken-pox is practically nil, as is that of mumps also; and rötheln has a very small fatality.

If we classify the indigenous communicable diseases of England according to their destruction of life, irrespective of age and sex, and of the number attacked, and take the Registrar-General's decennial figures for 1871-80, we obtain a comparative sequence of mortality. Phthisis and "other tubercular diseases" stand far above the zymotic class in

fatality, averaging respectively, per annum per million of population, from 1540 to over 2000, and from 640 to over 800 deaths; the former necessarily includes something more than tubercular phthisis; doubtless many respiratory diseases also enter into the category. Similarly, diarrhœa and dysentery, which are credited with 917 deaths per million, must include many obscure forms of diseases, of which they have been the most prominent symptoms. Apart from these, and enumerating the zymotic diseases in order of fatality per million of population, we have scarlet fever, 719; whooping cough, 512; measles, 379; enteric fever, 326; small-pox, 245; diphtheria, 121; continued fever, 105; typhus, 58; and cholera (nostras), 26. These mortality figures are those prevailing under the conditions of improved sanitary and defensive precautions prevailing in England during that period, and cannot be regarded as of any relative value apart from those conditions.

Increased or diminished susceptibility of a community to the incidence and fatality of infectious diseases is mainly influenced by season, by hygienic and social conditions, as density, occupation, etc., and by the sex and age distribution of the population.

Murchison states that typhus appears to commence and progress irrespective of season, but generally the prevalence has been greatest in winter and spring, and least in summer, the case-fatality remaining little affected; that season has little or no influence upon the prevalence of relapsing fever, the case-fatality also varying considerably, but winter appearing on the whole to produce greater mortality; that typhoid fever is by far most prevalent in the autumn, and least prevalent in the spring, season having very slight effect upon the fatality. Cholera has invariably occurred in England in the hottest months, or immediately after; influenza, on the contrary, in the coldest.

W. C. Maclean quotes Wenzel's observations in Quain's *Dictionary of Medicine*, to the effect that at Jahde, in Oldenburg, on the North Sea, he found the increase in the attacks of malarial fever coincident with a rise in temperature. In the charts constructed by him to illustrate the point, a constant precedence of the temperature-curve by twenty or twenty-five days, of the sickness-curve of attacks is to be

seen, so that three weeks increased temperature appeared to be necessary for the genesis of the malarial poison, and when in any year the medium summer temperature did not reach 59° F. the sickness remained at its minimum.

The seasonal curves of mortality, for all ages and both sexes, in various diseases in London, were elaborately calculated by Buchan and Mitchell,[1] and the following are some of the results :—

	Maximum.	Minimum.
Small-pox	January, February	September, October
Measles (1)	December	September
,, (2)	June	February
Scarlatina	October, November	March, April, May
Diphtheria	November, December	May, June
Croup	Dec., Jan., Feb., March	July, August
Whooping cough	March, April	September, October
Fevers	Sept. to Jan. (inclusive)	Feb. to August (inclusive)
Typhus (1)	Jan. to April (inclusive)	June
,, (2)	July	September
Typhoid	October, November, Dec.	May, June, July
Continued Fever	Dec., January, February	July, August
Erysipelas	Nov., December, January	July, August
Puerperal Fever	Nov., December, January	July, August, September
Influenza	Dec., Jan., Feb., March	July, August, September
Diarrhœa	July, August, September	——
Cholera	July, August, September	——
Remittent Fever	——	September
Rheumatism	November, December	August, September
Dysentery	July, August, Sept., Oct.	——
Phthisis	March, April	September

The exact measurements of the seasonal prevalence and virulence of a disease in a community can only be possible when complete and accurate registration of the morbidity and mortality of the disease is accomplished. The amended clauses of the Infectious Diseases (Notification) Act, 1889, as contained in the Public Health (London) Act, 1891, and the amended form of certificate issued by the Local Government Board under these clauses, have furnished the means of calculating the morbidity and case-fatality, as well as the mortality, of the infectious diseases in the metro-

[1] *Journ. of Scott. Meteorol. Soc.*, 1874-75.

polis, with an exactitude never before possible. As illustrative of this point the following comparison may be drawn.

Dr. Thorne Thorne, in his exhaustive monograph on diphtheria, gives the number of notified attacks and registered deaths in fifteen large towns of England for the three years 1888-90:—

	Attacks.		Deaths.		Case-Mortality per cent.	
January	448	1258	153	423	34.1	33.6
February	404		138		34.1	
March...	406		132		32.5	
April	337	1005	104	277	30.9	27.5
May	392		103		26.3	
June	276		70		25.3	
July	388	1140	124	310	32.0	27.2
August	317		86		27.1	
September	435		100		23.0	
October	561	1442	169	448	30.1	31.0
November	480		136		28.3	
December	401		143		35.6	
Total	4845		1458		30.1	

From the number of attacks and deaths the case-mortality has been calculated in the above table, and the figures show the last quarter of the year as the period of greatest prevalence, the first quarter as that of greatest virulence, the second quarter as the period of least prevalence, and the third quarter as that of least virulence. Comparing the number of attacks with the number of deaths, it will be seen that the deaths do not rise *pari passu* with the prevalence of the disease, but rather tend to hang back in proportion to increased prevalence. This is interesting, as it does not tend to show that diphtheria increases in virulence as it spreads, although instances given in detail by medical inspectors of the Local Government Board in many cases do strongly support this opinion, at least in the initial stages of an epidemic.

A point of interest, in reference to season, is the occurrence of two periods of maximum mortality, one during the cold and the other during the hot season. The seasonal prevalence must therefore be due to some variation

indirectly, rather than directly, related to season. Measles and, in a less marked manner, typhus have maximum curves of mortality both in winter and summer. This may be caused by the disturbing influence of epidemics upon averages, based upon the total figures of a great number of years. It may also be due to variations in habit, or social and hygenic conditions. The greater exclusion of air from the dwelling, and other domestic habits in winter time, must tend to the greater spread of infection in interiors, especially of such a disease as measles, to which measures of isolation and disinfection have not hitherto been applied. In fact habit, occupation, crowding, and social and hygienic conditions generally, exert powerful influences in modifying the prevalence and fatality of the infectious diseases, influences that are difficult to measure.

The effects of improved prophylaxis and sanitation have reduced the mortality of all zymotic diseases, excepting diphtheria, measles, and whooping cough. During twenty years from 1869–1888, the mortality from enteric fever fell from 390 to 169 per million in England. Diphtheria has notably increased, especially in towns. The increase of the infant and young population in towns means also greater aggregation in schools, *crèches*, etc., and the directly infectious diseases of infancy and childhood might be expected to show a proportionate increase. It is to this cause that Thorne Thorne attributes the increase of mortality from diphtheria in large towns. Measles and whooping cough show no decrease, being diseases not dependent upon sanitation, and to which prophylactic measures have not been applied.

Speaking generally, scarlet fever is most common in the mining and manufacturing counties of England.[1] The explanation offered for this is, that not only is the proportion of young children in the population of these industrial counties large, but that they live in more than averagely close aggregation, facilitating the spread of infection.

The crowding together of human beings in interiors not only increases the prevalence but also the virulence of the infectious diseases. Virulent forms of typhus, pneumonia, and tubercular phthisis are favoured by impure atmospheres, and even in the absence of specific infection the lowered

[1] *Registrar-General's Forty-seventh Annual Report*, 1884.

condition of health increases the susceptibility to attack when exposed to infection, and to a fatal issue when attacked.

Industrial conditions exert a powerful influence upon the mortality, especially upon such a disease as phthisis. Those industries in which exposure leads to respiratory diseases, and in which occupation in impure air, or a dusty atmosphere, causes pulmonary complaints, are most predisposing to the attack of tubercular contagion.

How far resistance to attack, and to a fatal issue, differ in the two sexes we have as yet little means of judging. There is considerable difference in the habits of the male and female sex, and also in the degree of exposure, these being again complicated by local industrial and social conditions.

For some reason or other, the male mortality from small-pox far exceeds that of females,[1] and the data furnished by the reports of small-pox hospitals show that a far larger number of male than of female cases is admitted, and that a much larger proportion of them terminate in death. To measles both sexes appear equally liable, but the mortality under two years is slightly higher in males, and over that age somewhat higher in females. The female sex throughout life, the first year possibly excepted, is more liable to scarlet fever than the male sex; but the attacks in males, though fewer, are more likely to terminate fatally. The mortality from diphtheria, after the first two years of infancy, is much higher in the female sex; diphtheria being the only zymotic disease, with the exception of whooping cough, which, out of equal numbers living, claims more female than male victims, and there is reason for assuming that the disease attacks more females than males. Dr. Downes considers this may be due to their greater physiological proclivity to take the infection, but Dr. Thorne Thorne observes that something depends on the full significance of the term "domesticity," and upon taking account of those acts of affection and tenderness which, in their relation to the sick, characterise females during the period of girlhood, as well as in mature womanhood.

Whooping cough is also more destructive of female life than male, and it is the only zymotic disease in which this characteristic presents itself at each successive age period;

[1] *Registrar-General's Fifty-first Report.*

it is also held that girls are much more liable than boys to contract that disease. The aggregate male death-rate from enteric fever exceeds that of females, but the female mortality is considerably higher from the third to the twentieth year of life. This appears to be due to greater fatality, since females between three and twenty years of age are considerably less liable to attack, according to fever hospital returns. Therefore it is the higher case-mortality, and not the greater number of attacks, to which this higher death-rate in females during this period is due. The Registrar-General significantly adds that this "shows clearly enough how dangerous it is to draw inferences as to the liability of different ages and sexes to any given disease merely from the mortality figures."

In reference to the influence of age, calculated upon a basis of very large numbers over a long period in the Registrar-General's Fifty-first Report, it is found that small-pox, measles, scarlet fever, diphtheria, croup, whooping cough, diarrhœa, and dysentery, are pre-eminently fatal in the first five years of life. The high rate of mortality also extends beyond this first age-period in the case of scarlet fever and diphtheria. Enteric fever does not exhibit in this first quinquennial period an excessive mortality, and the death-rates at succeeding age-periods show less variation than in other zymotic diseases; but its highest mortality occurs between the ages of 15 and 25 years. The mortality from small-pox decreases after the first five years until it rises again to its second maximum at the 20-25 age-period, due to the immunity produced by vaccination. In taking the years of the first quinquennial period separately, the highest mortality of small-pox is in the first year of life, and progressively decreases, under the influence of vaccination, through the remaining four. The death-rate from measles reaches its maximum in the second year of life, and then falls rapidly year by year, so that beyond the age of childhood it becomes insignificant. The statistics of scarlet fever were elaborately digested in the Forty-ninth Annual Report of the Registrar-General, the following conclusions being arrived at in reference to the influence of age. The mortality of scarlet fever is at its maximum in the third year of life, and after this diminishes with age, at first

slowly, afterwards rapidly. This diminution is due to three contributory causes :—(*a*) The increased proportion at each successive age-period of persons protected by a previous attack; (*b*) the diminution of liability to infection in successive age-periods of those who are as yet unprotected; (*c*) the diminishing risk in successive age-periods of an attack, should it occur, proving fatal. The liability of the unprotected to infection is small in the first year of life, increases to a maximum in the fifth year or soon after, and then becomes rapidly smaller and smaller with advance of years. The chance that an attack will terminate fatally is highest in infancy, and diminishes rapidly to the end of the twenty-fifth year, after which an attack is again somewhat more dangerous. Similar results were obtained and recorded by Dr. Whitelegge, in a paper upon this subject, in the Epidemiological Society's *Transactions*, 1888. From these facts we may conclude that, the longer exposure to infection is deferred the less likely is the individual to be attacked, and if attacked the less likely the disease will be to prove fatal. The diphtheria death-rate rises to a maximum in the fourth year of life, and then falls through successive age-periods until a slight rise occurs again in old age. The first fifteen years of life are those during which diphtheria is mostly recognised, and there is a special incidence of the disease, fatal and non-fatal, on the period 3-12 years.[1] Whooping cough proves most fatal in the first year of life, like diarrhœa and small-pox, after which the mortality falls year by year until it reaches insignificant proportions beyond the tenth year.

In the first three months of life small-pox and diphtheria prove more fatal than in later months, and diarrhœa proves most fatal during the earlier milk-feeding period of the first year; whereas measles, scarlet fever, diphtheria, and whooping cough secure few victims during the earlier part of the first year, but towards the end the death-rates of these diseases rise, those of the two former markedly.

As illustrative of the case-fatality according to age in certain diseases gathered from the most recent hospital statistics, the following figures extracted from the Report of the Metropolitan Asylums Board for 1890 may be quoted :—

[1] *Diphtheria.* Thorne Thorne.

TABLE SHOWING THE NUMBER, AGES, AND MORTALITY, AT VARIOUS AGES, OF CASES OF FEVER AND DIPHTHERIA ADMITTED INTO THE HOSPITALS OF THE METROPOLITAN ASYLUMS BOARD.

	Scarlet Fever.			Diphtheria.			Enteric Fever.			Typhus Fever.		
Ages.	Cases Admitted.	Died.	Mortality per cent.	Cases Admitted.	Died.	Mortality per cent.	Cases Admitted.	Died.	Mortality per cent.	Cases Admitted.	Died.	Mortality per cent.
Under 1	125	37	29.60	31	14	45.16						
1 to 2	495	161	32.52	100	77	77.0						
2 to 3	1,035	258	24.92	151	103	68.21						
3 to 4	1,486	255	17.16	190	104	54.74						
4 to 5	1,628	198	12.16	201	87	13.28						
Totals	4,769	909	19.06	673	385	57.20						
Under 5	10,531	2,153	20.44	673	385	57.20	201	28	13.93	86	2	2.35
5 to 10	15,169	1,089	7.18	547	195	35.67	894	77	8.61	242	1	0.41
10 to 15	6,100	228	3.74	215	32	14.88	1,623	217	13.37	370	14	3.80
15 to 20	2,544	92	3.61	128	8	6.25	1,604	295	18.38	352	28	8.04
20 to 25	1,283	45	3.50	90	8	8.89	1,054	211	20.02	239	49	20.50
25 to 30	611	27	4.42	49	1	2.04	689	163	23.65	152	34	22.36
30 to 35	335	21	6.27	28	...	...	401	107	26.68	159	47	29.74
35 to 40	154	11	7.14	17	2	11.77	239	63	26.36	129	47	36.43
40 to 45	66	6	9.10	8	2	25.0	126	28	22.23	168	81	48.21
45 to 50	29	1	3.45	4	1	25.0	72	22	30.56	95	42	44.21
50 to 55	21	1	4.76	1	1	100.0	33	11	33.34	60	36	60.00
55 to 60	2	1	50.00	2	1	...	12	6	50.00	32	24	75.00
upwards	4	1	25.00	1	1	100.0	12	4	33.34	37	27	72.97
Totals	36,849	3,676	9.97	1,763	637	36.07	6,960	1,232	17.70	2,121	432	20.36

The susceptibility to the attacks of infectious diseases, and to a fatal issue when attacked, vary also considerably in different races and families, this difference forming part of the complicated question of immunity. Why the dark races should be more immune to yellow fever and more susceptible to small-pox than the white, why some families should be more prone to the exanthemata, and others to tuberculosis, and numerous other deviations of morbidity and mortality from infection, all form part of the unsolved problem of immunity.

Murchison states that typhus and relapsing fever cause the greatest mortality at the commencement and at the height of epidemics, and that as the number of cases diminishes the mortality declines. Cholera also has a higher mortality at the commencement of epidemics. This may be due to the killing of the most susceptible individuals in the earlier periods. In the course of epidemics two opposing factors seem to be at work. It would appear as if, in certain communicable diseases, the passage of the virus successively through susceptible individuals increases its virulence and fatality, so that the comparative mortality tends to increase. At the same time, as the epidemic progresses, having seized the most susceptible, it meets with more and more resistent individuals. So that, in ascending to the maximum mortality the attacking parasites gain the victory; at this point the tables are turned, and victory inclines to the defending hosts, the mortality diminishing, and the morbidity ultimately subsiding.

Some disease germs appear to attack equally the healthy and the enfeebled, some prefer the exuberantly healthy, and some have a preference for those whose vital energy is lowered. For instance, the tubercle bacillus is almost ubiquitous, and attacks those whose health and vitality are depressed below a certain level, by surroundings, or by habits, or by pre-existing disease. On the other hand, the typhoid bacillus and the contagion of epidemic cerebro-spinal meningitis are apt to attack robust young adults. Again, some attack indifferently the feeble and the robust, as small-pox.

The peculiar selective power of some micro-organisms is exemplified in animals. Thus anthrax, although exceedingly

fatal to man and cattle, is innocuous to cats, dogs, and pigs; and the septicæmic bacillus acts virulently on house mice, but is without effect on field mice.

So far as animals are concerned, the temperature of the body is a most important factor in immunity. The frog and the fowl are both immune to anthrax, the temperature of the former being below, and the latter above, the optimum temperature for the growth of the bacillus. Pasteur found that the fowl was rendered susceptible to anthrax by reducing its temperature to 28° C., and raising the temperature of the frog produces a similar result. The chemical composition of the tissues must also be taken into account, for it has been conclusively shown that cultivation media derived from the tissues of different animals produce different rates of growth of implanted microbes.

The diminished or increased fatality of an epidemic was formerly summarily explained as due to temperature, humidity, or epidemic constitution, but now that contagium is regarded as a living entity, the variations must be sought primarily in the attenuation and intensification of the virulence of the living parasite, whether these phenomena be due to external influences or to the individual invaded. The vitality and fertility of organisms vary at different periods of their existence. They increase up to a certain point, at which, owing to the consumption of the pabulum or to the accumulation of the products of their secretion, they commence to decline, and becoming weaker and weaker, the micro-organisms die, or ceasing their activity, form spores and pass into a condition of latent vitality. Pasteur first observed the fact that the virulence appeared to diminish with the age of the virus in experimenting with chicken cholera. He found that cultivated, from culture to culture, at intervals of one day, the virulence was maintained at its normal, and fowls succumbed to the inoculations; but that if the cultivations were made at intervals of months from one culture to another, upon inoculation, fowls recovered after sickening. The microbes being again found in the tissues proved that the effect was not due to their absence but to their attenuation, and that the fowls had suffered from the disease in a modified form was proved by the fact that they were refractory to virulent

inoculations; in fact they had been vaccinated with chicken cholera. That this attenuation was not due to the senility of the microbes themselves, but to the access of oxygen, Pasteur demonstrated later on by cultivation in open and in closed tubes, and this was put to a practical test when closed tubes of the virus were sent to Australia in 1888 for the purpose of exterminating rabbits. The contents of the tubes upon arrival were inoculated into rabbits, and were found to have lost none of their virulence. The attenuation of chicken cholera can thus be regulated according to the length of the exposure to the effects of the air, and it is probable that similar effects are produced by oxygen upon other bacilli reproducing by fission only, like those of chicken cholera. But it is otherwise with the spore-producing forms. Anthrax bacilli, for instance, exposed to the air, commence to form spores, and so shield themselves from its influence. Pasteur found in 1881 that anthrax bacilli could not be cultivated at a temperature above 113° F., but that by cultivating them a few degrees below this point growth took place without the production of spores, and that according to the length of time this was maintained, measured by days, the attenuation proceeded until at the end of a few weeks the cultivation became sterile. The difficulty of the spore formation was thus overcome, and the attenuation of anthrax to any desired degree accomplished, and this was put to the practical test later on by the vaccination of cattle with anthrax. Duclaux and Arloing subsequently showed that the same effect was produced on microbes by exposure to the sun, gradual attenuation leading to sterilisation. We have therefore experimental confirmation of the fact that exposure to air and light, and the influence of wind and sun, weaken and ultimately destroy specific microbes.

Chemical substances have also been demonstrated to possess the power of attenuating microbes, as well as destroying them. Chamberland and Roux state that 1 part in 600 of carbolic acid, or 1 in 2000 of bichromate of potash, will prevent anthrax bacilli forming spores; and Kossiakoff has observed that, cultivated in media containing progressively increasing doses, microbes will adapt themselves gradually to chemical disinfectants, just

as they adapt themselves to progressive increase of heat.

Again, the virulence of the contagium is modified according to the race or species of the individual through which it passes. The power of microbes derived from animals highly susceptible to their influence, is diminished by passing them through animals more refractory to their influence.

The age of the individual—human or lower animal—has an important influence on the action of the virus. The younger the animal, the more sensitive is it to the effects of contagia. The same applies in a measure to size, the smaller animals of the same or similar species being more susceptible than the larger. So that attenuated anthrax virus, ceasing to kill cattle, will still prove fatal to sheep; if further attenuated the sheep will escape, but not rabbits; and it may be still further attenuated till only of sufficient strength to kill young guinea-pigs; and further still, younger and younger mice. Chicken cholera may be similarly attenuated through fowls, pigeons, and small birds.

By reversing the process, and cultivating the virus through animals of increasing age and size, Pasteur has succeeded in demonstrating that the virulence is increased, until it ultimately proves extremely fatal to older and large-sized animals.

It was in the epoch-marking Croonian Lecture of 1889 that Pasteur stated that the virus of certain communicable diseases—swine erysipelas, hydrophobia, etc.—can be so attenuated, by repeated cultivation through suitable hosts, as to be rendered perfectly innocuous; and further, that by reversing the process, and passing the attenuated virus through the bodies of suitable hosts, the contagion can be so fortified as to become extremely virulent.

As the passage of anthrax and of rabies through one series of animals attenuates the virus, and through another series augments the virulence of the contagion, so the cultivation of organisms in one form of artificial medium produces results different from cultivation in another. The *Bacillus prodigiosus* on proteid substances gives rise to a red pigment, on sugar it forms lactic acid; the *Bacillus pyocyaneus* on bouillon develops a green fluorescence, on egg albumen this power is lost.

There appears, therefore, to be little doubt that, under gradually altered conditions, the characteristics of microbes become greatly modified. The attenuation and intensification of various contagia produced by variations in the mode of cultivation, or by passing them through various animal organisms, and the effects of antagonistic and of auxilliary microbes, all point to the same conclusion. Nevertheless, the contagia of the infectious diseases breed true—that is, they do not become converted one into the other; nor is it necessary to look for such a result to prove the great variation of diseases in virulence and geographical distribution.

Regarding the fact that the presence of one organism modifies another, the bacillus of diphtheria acquires greater virulence in growing on the surface of the fauces in company with streptococci, so that mild cases appear to give rise to progressively fatal forms of attack. Small-pox is stated to benefit tubercular leprosy (Daniellsen and Boeck). The nidus in which one species of micro-organisms can no longer grow forms a suitable nidus for others. Thus yeast cells prepare the nidus for the acetic bacilli, these again for putrefactive bacilli, these again for moulds. Some microbes again secrete substances that have an inhibitory action, and render the nidus unsuitable for others.

Does a contagium vivum possess the property of communicability *ab initio* or acquire it? Upon this arises the question whether microbes are capable of modification (*a*) in the direction of increased adaptability to environment; (*b*) of increased virulence; and (*c*) of increased communicability. There is no doubt of the increased power of adaptability possessed by microbes, in successive generations, to temperature, within certain limits. Experiment has established this fact; and their increased adaptation to variations of moisture and soil, or nutritive material, must also be granted. Further, we know that this adaptation increases or diminishes their virulence; attenuation and intensification may thus be artificially produced in the laboratory. Increased communicability is as much dependent upon the increased quantity of a contagium produced, so that the opportunities of contact are multiplied and the exposure longer continued, as upon increased pathogenicity, and the pathogenicity being intensified, the chance of productive

insemination, and consequently of communication, is further increased. The question still remains: may non-pathogenic microbes become pathogenic?

Leuckart (in his *Parasites of Man*) is of opinion that "animal parasites have, by accommodating themselves to the condition of a parasitic life, in course of time sprung from creatures originally free. The mode of origin which we thus assert for these creatures is in principle precisely the same as that which we also assert, in consonance with the doctrine of descent, for the individual free-living forms, when we maintain their development to have been brought about by means of various influences, either directly from one and another or from a common original form." This refers to the gradual transition to a parasitic mode of life, requiring ages of time to complete, and in no way assumes that contagia do not breed true, or that non-parasitic animals become parasitic within our observation periods. The same abstract opinion may be safely held with regard to the vegetable parasites, but it does not answer the question whether so-called non-pathogenic microbes may upon access to the human organism become pathogenic.

Our knowledge of non-pathogenic micro-organisms is so limited that we know little of the environment requisite for their survival and multiplication, and many micro-organisms classed as non-pathogenic are only so classed because they have not been found pathologically. But it cannot be assumed that a microbe which shall find in or upon the human organism a nidus and conditions as suitable, in all respects, as those in which it has its habitat externally, cannot become parasitic, although it has not been so discovered to occur pathologically. Experiments with the *Aspergilli* conclusively show that the more the temperature optimum and the conditions of nutrition approach those favourable to the growth of any variety, the greater is the tendency to become parasitic when artificially inoculated or injected.

The subject of immunity is extremely complicated, and although a vast number of facts are accumulating, definite views are only slowly being elucidated. Mere escape from infectious disease does not demonstrate immunity, and as so many factors may intercept infection of the individual under natural conditions, we can never possibly hope to discover

the causes of immunity except by actual experiment. The effects of locality, climate, and season, especially as to temperature, humidity, and nidus, the effects of family, sex, age, and occupation, are all conditions that increase or diminish the tendency to the spread of the specific diseases. The escape of a population, of a family, or of an individual, may each be due to the same or to different causes. Neither can resistance be strictly regarded as immunity, although the causes of immunity may explain some of the causes of resistance to infectious disease. The power of resistance may be diminished by enfeebling habits or a low state of health, and increased by opposite conditions, and by acclimatisation after change of residence.

The liability to disease varies with the individual, from extreme susceptibility on the one hand to extreme immunity on the other. Immunity to disease may be congenital or acquired. Age and sex may be considered as congenital or developmental modifications. The acquisition of immunity may be brought about naturally by a previous attack of the disease or by acclimatisation, or artificially by the inoculation or vaccination of the attenuated virus into the blood or tissues. Immunity from future attack, enjoyed by those who have passed through certain of the infectious diseases, is a matter of common experience, but the explanation of this phenomenon remains an unsolved problem. It is more especially in certain of the acute exanthematous diseases that the phenomenon is most marked; but even in those diseases in which the protection is most recognised exceptions occur. After no disease can an absolute statement be made that permanent and total immunity has been acquired, and after some diseases increased susceptibility takes place, as in erysipelas, diphtheria, malaria, and rheumatism.

Various theories have been advanced to account for the immunity against a subsequent attack acquired after recovery from specific febrile diseases. These theories may be reduced to four in number, and may be known as the vital, the exhaustion, the antidote, and the phagocyte theories. The first and earliest of the explanations of immunity attributed it to the vital resistance of the tissues. The tissues having once been subjected to the virus of

a specific disease, and having successfully resisted it, acquired thereby increased power to resist future attacks.

Grawitz attributed immunity by vaccination to the victory gained by the cells over weakened contagium, which effort strengthens the cells against unattenuated contagium; and Dreher suggested that inoculation with kindred bacteria, less virulent in their effects, might produce immunity against the germs of infectious diseases similar in their qualities to those inoculated, but more virulent, since kindred species of bacteria have similar qualities.

The second theory attributes certain effects to the disease germs, which are credited with having exhausted the particular pabulum necessary for their growth and multiplication, rendering a second attack impossible on account of the want of nutrition.

The third theory also attributes certain effects to the invading microbes, and assumes that they produce and leave behind them substances which act as antidotal poisons to their successors. This assumption of Klebs has been more or less verified by the study of the products cast off by microbes in the form of *ptomaines* and *albumoses*. The two latter hypotheses presume that the tissues remain in an unchanged condition, and do not possess, or else lose, the power to regenerate the pabulum, or to expel the products remaining behind. So far as retention of the products is in question, it must either be assumed that they are retained by a natural selective process, or that the tissues, having acquired the power, still continue to reproduce the protective products.

The fourth and most recent theory follows on the lines of the first, and attributes to the cells of the blood and tissues not only a defensive but an offensive power as germ destroyers. The amœboid white corpuscles of the blood, named by Metschnikoff phagocytes, enveloping, absorbing, and destroying the intruding microbes, acquire in the struggle greater power to resist the detrimental effects of the excretal products of the intruders, and greater capacity for their destruction. The white corpuscles of the frog have been actually observed to seize, envelop, and disintegrate the bacilli of anthrax, microbes harmless to frogs, but deadly to many other animals.

The phagocytosis theory assumes that the leucocytes wage physical warfare with intruding microphytes, but more recent researches have thrown doubt upon this, at least as explaining all the phenomena of the destruction of microbes, to the exclusion of the effect of chemical products.

Emmerich attributed immunity from infectious diseases to a modification of the chemical process going on in the cells, the newly-formed chemical compounds acting as microbe killers within a few hours, according to his experiments, which were mainly on swine erysipelas. Emmerich and Mastbaum concluded from this that the tissues of animals rendered immune against infectious disease, if extracted, would confer immunity against particular infectious diseases, and experiment proved the conclusion correct in certain cases. An extract was made of the tissues of rabbits that had been rendered proof against swine erysipelas. Mice and rabbits were inoculated with the extract at the same time as swine erysipelas was inoculated, and the animals survived; whereas control animals, that only received the swine erysipelas, died. The extract did not appear to produce so great an effect upon the bacilli in artificial cultivations as it did when meeting with them in the living tissues. Babes and Cerchez[1] confirmed the fact that the liquids or cells of animals, rendered immune or naturally proof against rabies, were capable of transmitting immunity to other animals. On the other hand, Straus, Chambon, and Menard, reported to the Académie des Sciences in December 1890, that the transfusion of nearly the whole of the blood of calves, previously protected by cow-pox vaccination, failed to protect animals of the same species.

Bouchard found that among the substances secreted by microbes are some that exert an inhibitory and others a favourable effect upon their development, multiplication, and action, and that some pathogenic microbes secrete substances that confer subsequent immunity upon animals inoculated with them. If an animal be inoculated with these substances, at the same time as with a pure culture of the bacilli from which they were obtained, the disease runs a more rapid course,

[1] *Ann. de l' Inst. Pasteur*, 1889 and 1891.

but if inoculated with these products a few days before the pure culture is inoculated, the disease is delayed or prevented. By cultivating antagonistic bacteria together the stronger retards the development of the weaker, and if an animal be inoculated with the products of the stronger at the same time as the active principle of the weaker, the effects of the latter are delayed and enfeebled. Some microbes, on the contrary, assist others, and by means of them a disease may be communicated which would otherwise be resisted. In the case of anthrax and diphtheria an injection of the albumose, or of the soluble products of the bacteria, during the course of an attack of one or other disease accelerates rather than interferes with its regular course. Koch utilises a somewhat analogous process in his tuberculin injections for tuberculosis.

Nuttall, in 1888, discovered that various bacteria were destroyed by fresh blood serum. Buchner and Nissen confirmed this, and Bouchard further found that the bactericidal power of the blood serum of an animal rendered immune is greater than that of a susceptible animal; experiments with cholera, anthrax, and other diseases have been made in this direction. The former does not hold good of tetanus and diphtheria, as Behring and Kitasato have shown, since the microphytes of these diseases do not enter the blood serum, but grow upon the surface, and diffuse their toxic products in the blood-stream, by which means their lethal power is exerted. Recourse was then had to the blood serum of immune animals, and they found that although the serum has no influence over the bacilli of tetanus and diphtheria, it acts as an anti-toxine, and renders the animal immune against the effects of the toxic products of the microphytes. Drs. Klemperer have also found that in pneumonia, although the blood serum of man and of animals (rabbits) rendered immune by an attack of the disease will protect susceptible animals, it will not cure, and have shown that two substances are produced by the microphytes—first a toxine, and later an anti-toxine—and that it is the latter that produces immunity, and also by its ultimate predominance accounts for the crisis of the disease in man.[1] Fraenkel

[1] *Berl. Klin. Woch.*, 1891.

and Brieger had, previous to this, also found two toxalbumens in the products of diphtheria bacilli, the one the specific poison and the other the antidote; the effects of inoculating the products varying according to the temperature they had been artificially subjected to, and whether the inoculation took place before or after the commencement of the disease.[1]

The serum of rat's blood exerts a bactericidal power upon anthrax bacilli, due, as Metschnikoff and Roux have shown, to direct effect upon the virus and to *chemiotaxis*, or attractive power on leucocytes, encouraging phagocytosis. The gathering together of leucocytes at an infected centre is now mainly attributed to this chemiotactic effect; they scent the attraction and direct their course to it, not merely because it is a foreign body, but because it is an attractive substance.

Burdon Sanderson, in his "Croonian Lectures," divides the types of action of microbes into *biotic*, those that act mainly by their vital action and dissemination, as in splenic fever and tuberculosis; and *toxic*, those that mainly act by producing toxines, and diffuse them in the blood tissues, as diphtheria and tetanus; and regards the contest between invading microphytes and the living elements of the tissues not as a hand-to-hand fight, but as a struggle between the one and the other by means of toxines and anti-toxines.

Vaccination is but part of the subject of inoculation specialised. Inoculation may be preventive or curative—preventive in order to render the individual immune against the attack of a disease; curative in order to mitigate or abort the disease in an individual attacked.

From a curative aspect, Dr. Behring contributed a suggestive paper on "Disinfection in the Living Body" to the International Congress of Hygiene, 1891, in which he says that Pasteur's work on hydrophobia and Koch's on tuberculosis have held out the hope that for the various specific diseases specific remedies may be found; and recent researches on tetanus, diphtheria, anthrax, etc., have shown that it is possible even within the body to combat successfully the various specific poisons produced in these diseases.

He enumerates four possible ways of accomplishing this—(1) By killing the disease-producing germs; (2) by

[1] *Berl. Klin. Woch.*, 1890.

hindering their growth; (3) by counteracting the power or function of pathogenic organisms of producing poisonous products; (4) by antagonising the action of, or destroying altogether, the various toxic products produced. The first and second may be regarded as two stages of the same process.

Behring then mentions his injection experiments with a mixture of corrosive sublimate and chloroborate of soda on mice inoculated with anthrax, by which fatal results are postponed or prevented in certain cases; and the results obtained by Kitasato and himself in tetanus and diphtheria, respectively, with trichloride of iodine, and with a double salt of chloride of sodium and gold, and zinc preparations. These chemical agents only give a certain proportion of success, and when injected early and near the seat of the original inoculation. The blood of immune animals, on the other hand, acts both locally and generally, and at all stages of the disease. The observations of Behring and Kitasato show that tetanus in mice can be cured by the injection of the blood of rabbits rendered immune against the disease, just as Roux and Yersin demonstrated similar results in diphtheria. Behring holds that since the healing action of the blood is present in extravascular cell-free blood-serum, and that as the diphtherial poison may be destroyed without destroying the bacilli, therefore the power of the serum of immune animals is not dependent on its living elements, but upon their products. Ehrlich has pushed this effect of organic products to further proof by rendering mice and rabbits so immune to vegetable albumens, especially those of the castor-oil plant, that they can withstand enormous doses. Von Foder[1] has also shown that immunity to certain communicable diseases in animals appears to be in proportion to the germicidal power of the blood due to its alkalinity, and that increasing the alkalinity increases this power.

Here the complex question of the cause of acquired immunity remains, the point at issue being mainly the relative values to be attached to the offensive products of microbes and the defensive power of the white corpuscles and serum of the blood.

[1] *Centralbl. für Bact.* No. 24.

PART III.

DEFENSIVE MEASURES AGAINST COMMUNICABLE DISEASES.

CHAPTER I.

QUARANTINE.

QUARANTINE has been held to include all those measures of segregation and sequestration imposed upon persons and objects susceptible of transmitting an infectious disease with which they have been in contact. Originally the word indicated the forty days that appeared necessary for the contagion of the plague to consume itself in infected or suspected persons or objects. It is now applied to measures of segregation and sequestration regardless of their duration. The mediæval physicians reckoned the separation of ardent or acute diseases from the chronic by the forty days' assumed duration of the former, and ancient superstitions and Biblical events tended to confirm this period as that of the duration of the pestilential diseases. (Hecker.)

In 1348, the year of the extension of the Black Death, it was noted by many observers, and specially recorded by Gabriel de Mussis, who fled from the Crimea to Plaisance in France, that ships and passengers from the East conveyed the disease. In the same year Venice, then the centre of maritime commerce, appointed three *Proveditors of health* to take measures against the plague. In 1374 Count Barnabo issued a decree at Reggio, on the Tessone, in Modena, that any person attacked by the disease should immediately quit the city, fortress, or castle, for tents in

the open country until recovery or death; that persons in attendance on the sick should not consort with others until after the lapse of ten days; that the priests should examine and notify the infected sick to the Inquisitors, and that all goods and property of persons infected, or who conveyed infection, should be confiscated to the use of the Church, and none but those appointed should, under penalty of death and confiscation, attend upon the plague-stricken.

In 1382 Chalin de Vinario demonstrated that contagion was the cause of the spread of the plague. In 1383 Count Barnabo forbade the admission of persons from infected localities under penalty of death; and his successor, Viscount John, in 1399, ordered the city gates to be guarded against the admission of strangers from infected places, and infected houses to be fumigated and thoroughly ventilated for a long period, clothes and bedding to be washed and dried in the open air, bedsteads to be exposed for days in the open, and all refuse matters and rubbish to be burnt.

The first lazaret, or rather plague-house, was founded in 1403 by the Proveditors of Venice on an island near that city, but only those actually attacked by plague were at first admitted. Later in the century a few other maritime cities on the Mediterranean adopted similar measures, amongst others Marseilles. In 1526 Marseilles established the first quarantine port in the adjoining island of Pomègue, where ships, goods, and passengers underwent a period of seclusion. During this century the system of quarantine extended to most of the maritime cities of the Mediterranean, and many inland cities adopted similar precautions. In 1546 the work on contagions and contagious diseases by Fracastor, the Venetian, declaring contagion to be exhaled by the body, infecting those at hand directly through the air, and those at a distance through the medium of fomites, gave a further impulse to measures of exclusion. Gradually the practice of quarantine extended over the civilised world, and by intermittent stages, with the advent of epidemics, the measures increased in severity, and the penalties became more rigorous. Torture and death awaited alike those who remained in the city when ordered away, and those who entered when forbidden access.

In the sixteenth century not only were ships with their passengers and cargo detained in prolonged quarantine, but towns also were surrounded by sanitary cordons and completely blockaded for long periods, and even individual houses in the towns were closed against exit and entrance, so that food and necessaries were only obtained with difficulty and by the most circuitous methods of exchange, whilst politics, commerce, and social intercourse stagnated. The paralysing effects upon maritime intercommunication, and the isolation of towns from each other, by reducing the number of possible points of introduction, demonstrated vividly the lines of invasion and advance of epidemics, and attention became more and more directed towards concerting measures for preventing invasion through maritime ports.

During the eighteenth century maritime quarantine and lazarets extended, on the Mediterranean littoral specially, and became of increasing importance with the subsidence of the severity of inland pandemics. The quarantine services under Boards of Health, with their stations, lazarets, detentions, disinfections, numerous attendants, and complicated ordinances, became large organisations. The less frequent invasions of Europe by plague, against which maritime quarantine was almost solely directed, led to the neglect and dilapidation of lazarets and to laxity of administration, alternated by spasmodic applications of the most severe mediæval regulations in time of panic, until the protests of John Howard at the end of the eighteenth, and the advent of cholera and yellow fever at the commencement of the nineteenth century, revived the interest in the prevention of pandemics, and shook the confidence placed in quarantine, as then practised.

In order to trace the cause of the revulsion of feeling against quarantine, a brief review of its administration at the commencement of this century is necessary; and as France has always taken the lead in these measures, the French system has formed the type of others. At a maritime port the administration of the service was controlled by a *Bureau de Santé*. On a carefully selected and isolated site, generally an island or a peninsular, was constructed a *lazaret*, to which the passengers of ships were transferred to undergo

the quarantine, disembarking at a *quarantine port* or station in proximity to the lazaret. Every captain of a ship, before entering the commercial port, was required to deliver a Bill of Health recording the condition of health of the place whence he hailed, as well as of the condition of the ship and of its contents at the time of departure, and also a *declaration* of particulars, and of the present condition of the passengers and cargo. The Bills of Health were divided into three classes; *clean* (*patente nette*), indicating that no suspicious form of disease existed at the point of departure; *suspected* (*patente soupçonnée*), recording that the port of embarkation was in commercial relationship with an infected place, or that suspicious disease was prevalent; *foul* (*patente brute*), that plague prevailed in the place whence the ship had arrived. The ship then took up a position assigned to it in the quarantine port, and underwent a preliminary period of observation (*periode de serein à bord*) of two to eight days' duration. At the termination of this the passengers and cargo were transferred to the lazaret to undergo the required period of quarantine, which extended to eighteen or more days, in extraordinary cases even to fifty or sixty days, the death of a passenger requiring the quarantine to be recommenced. Before "*pratique*" was given, disinfection was performed by fumigations and sea-water washings of passengers, cargo, and ship.

These measures, designed for plague, were applied also to cholera and yellow fever, and were embodied with modifications in a lengthy Convention, accompanied by an elaborate International Sanitary Code, at the International Sanitary Conference held in Paris in 1851, in which representatives of twelve European powers took part. But there was no proof that cholera and yellow fever were communicated by aërial means like plague and typhus—in fact, the evidence then available tended to show that they did not spread by contact, whether direct, that is, with the body, exhalations, or breath of an infected person; or indirect, that is, with some object that had touched the infected person. Further, that ample ventilation and thorough cleanliness tended remarkably to prevent the spread of plague, which disease was becoming less frequent and more localised. The first and second reports on quarantine, made by the General Board of

Health to Parliament in 1849 (cholera), and 1852 (yellow fever), were based on these facts, and in recommending the substitution of sanitary measures for quarantine, the Board were supported by evidence that such measures, unlike quarantine, which only aimed at exotic diseases, reduced also the prevalence of endemic communicable diseases; that the improvement in the sanitary condition of ships and of towns actually rendered quarantine unnecessary, and that its enforcement diverted attention from permanent fundamental measures by causing reliance to be placed in temporary and superficial obstructions to inter-communications. Furthermore, that before the barrier of quarantine could be strictly imposed, the early seeds had already been sown in the country from which it was sought to exclude the disease, and were preparing the way for a general outbreak.

It was in 1849 that Snow first broached the theory that the intestinal discharges of persons suffering from cholera contained the cause of its extension, subsequently establishing its correctness by proving that the water supplies contaminated by these discharges were the media by which it was mainly spread. He showed that during the epidemics of 1848-49, and of 1853-54, the incidence of cholera mortality was in direct proportion to the foulness of the water of the several London water companies drawing their supplies from the Thames. About 1859 it was shown that enteric fever spread in the same manner.

Subsequently another objection was raised to maritime quarantine—namely, that it entailed also the establishment of inland quarantine, or, in other words, necessitated the completion of an encircling barrier entirely round the country, guarding the land frontiers as well as the sea coasts at every point. The difficulty of maintaining such a perfect blockade against the importation of disease was stupendous, and doomed to failure at many points. The leakages plunged a country into still further difficulties, for when once the disease was introduced into a few towns, these again must be cut off from communication with the rest of the country by sanitary cordons, a sanitary cordon within a quarantine circle. A town was thus compelled ultimately to take measures to free itself from the disease by excommunicating infected houses, and the occupants of a house

again to protect themselves by endeavouring to isolate the infected sick.

But at that time no proper provision had been made for the isolation of the sick in the first instance, and consequently the omission necessitated the building up of this elaborate and costly system, which tended to fail most when most required. It was answered that, as the pest-houses of the Middle Ages failed to check the plague, so in epidemic periods the isolation of cases as they occurred would be insufficient to keep pace with the extension of disease. But on the other hand it was shown that the extension was mainly dependent upon sanitary conditions, and the remarkable exemption of the rebuilt part of Hamburg from cholera in 1849, and other instances, impelled the General Board of Health to the conclusion that the first and foremost requisite to combat imported epidemics was the improvement of local sanitary conditions. When these conditions had been improved it would be found that the number of infectious sick would be reduced, and not exceed manageable proportions.

The Board of Health recommended definite practical measures in substitution for maritime quarantine. Instead of detaining all vessels arriving from ports which happened to be the seats of epidemic disease, it was proposed to detain only persons actually labouring under epidemic disease. Instead of keeping the parties infected together on board their own vessel, or in a building of the description of those used as lazarets, it was proposed to separate them, as far as practicable, and remove them to places provided with suitable accommodation. Instead of arresting vessels and detaining passengers, amongst whom there might be disease, until they were sent to a quarantine station, possibly distant from the port of arrival, it was proposed to give medical attention at once upon arrival for their own proper relief in the first instance, and not as sacrifices to the false notion of security to persons on shore. Instead of restricting authoritative care to certain epidemics from distant countries, and omitting attention to all others, it was proposed that immediate attention and relief should be provided for all cases of epidemic disease whatsoever, as well to those which might be contracted in port as to those which were

brought into it. Instead of detaining cargoes, it was proposed to immediately discharge them; universal experience having shown that the persons employed in opening packages of goods at quarantine stations had never contracted plague, yellow fever, or cholera, or any other supposed contagious disease therefrom. More recent experience has shown that the last opinion requires modification; dirty linen and rags are known to spread some diseases, especially small-pox, and possibly cholera; these must therefore be excepted from this somewhat sweeping statement. But even then detention in quarantine would not prevent these from carrying infection, and as there are difficulties in their disinfection, it only remains open to prohibit their importation, and to destroy them, if, nevertheless, they arrive.

It will thus be seen that the French and English systems for the prevention of invasion of a country by communicable diseases proceeded from opposite ends of the pole, both aiming at the same point. The one, based on the older theories, endeavoured by exclusion *en masse* to prevent infection from entering; the other, based upon more recent experiences, endeavoured to render a locality immune, and to deal with imported infection in detail.

In a pamphlet upon the International Conference of 1851, published in London in 1859, Dr. Gavin Milroy addressed two interrogatories to the medical profession:—"1. What evidence is there to show that any of the three diseases against which quarantine is especially directed—viz., cholera, yellow fever, and the plague—has ever been introduced into any place or country by a vessel on board of which no case of disease had occurred during the voyage, and which was also free from sickness on arrival? 2. On what trustworthy evidence rests the doctrine, that whilst the lapse of five days exemption from any signs of the cholera among the crew and passengers in a ship is considered to be a sufficient guarantee against the risk of that disease being imported, double and triple that period is necessary for the like security in respect of yellow fever and the plague?"

Although at the Conference in 1851 provision was made for the sanitary supervision of Turkey and Egypt, at the International Sanitary Conference of Constantinople in

1866 more complete measures against the extension of cholera from the East were considered. It was then recognised that cholera was endemic in India, especially in the valley of the Ganges, that it spread by the agency of man, in proportion to the amount of intercommunication and the rapidity of the method of travel, and that the diarrhœal or choleraic discharges were the means of propagation, the incubation period not exceeding a few days. Sea passages and railroads were held to be more rapid and certain than caravan routes, and deserts were regarded as barriers. Pilgrimages, fairs, army encampments, and large congregations of persons favoured the extension of cholera, in proportion to neglect of the purity of air, water, and soil, and to overcrowding. The progress of the disease was traced into Europe overland through India and Persia, and also through Arabia, from secondary *foci* derived from sea transit. The establishment of quarantine stations in the Red Sea, under international control, was advised, and a special sanitary service for the Hedjaz and the Mecca pilgrimages. An inland quarantine service across the overland routes was also suggested.

At the International Sanitary Conference in Vienna in 1874, a considerable modification of opinion commenced. Inland quarantine was rejected as inadmissible. The recommendation of the Conference of Constantinople to establish a strict quarantine in the Red Sea, in order to prevent the importation of cholera into Europe, was approved. This being regarded as the strategic point in the line of defence, tended to weaken reliance upon quarantine in western ports, and medical inspection was admitted to consideration as a possible substitute in conjunction with local sanitary measures. The memorandum of Sir John Simon, medical officer of the Privy Council, expressing the views of the Local Government Board[1] upon the prevention of cholera, materially influenced the opinions of the delegates. The precautions recommended in detail the various means applicable for the removal of filth, and the protection of water supplies, combined with careful disinfection of the discharges of any persons who might be attacked.

[1] *Report of Med. Off. to the Privy Council of Loc. Gov. Board*, 1874.

The International Sanitary Conference held in Washington, U.S.A., in 1881, was attended by the representatives of twenty-seven States, including all the governments of Europe, except Switzerland, and discussed the measures desirable to prevent the spread of yellow fever as well as cholera. No uniform agreement, however, was arrived at on all points, but certain governments adopted some of the recommendations.[1]

The invasion of Egypt by cholera in 1883, and of Europe in 1884, led to the International Sanitary Conference at Rome in 1885. The delegates of the powers interested were their ambassadors or diplomatic representatives, assisted by technical medical delegates. The delegates traced the course of shipping from its point of departure from ports and cities where cholera is endemic—Calcutta, Bombay, etc.—and followed it through the Red Sea, the Suez Canal, the Mediterranean, to the open ocean. Subsequently the indications for inland precautions were considered. The principal measures definitely recommended were, the desirability of securing correct statements of sanitary conditions by the presence, on large vessels, of government medical officers independent of shipping companies; the disinfection on board, by means of steam chambers, of all soiled or dirty articles; the enforcement of strict precautions against the spread of cholera by the pilgrims to and from Mecca. With regard to the detention of ships, the powers represented expressed opinions that ranged them in three groups. Turkey, Spain, Mexico, Brazil, etc., were in favour of the continuance of long quarantines; France, Germany, Austria, Hungary, Switzerland, Russia, Sweden, Norway, Italy, Portugal, yielding to the data of modern science, whilst desiring the curtailment of quarantine, were in favour of imposing such detention as they considered necessary upon travellers and commerce; whilst England and India advocated free passage, and no detention.[2]

But the greatest stress was laid by the advocates of quarantine upon the inspection by an international official of all vessels passing through the Red Sea, the points of

[1] *Trans. Americ. Med. Assoc.*, 1881.
[2] *Annales d'Hyg. Publ.*, 1885, No. 1.

inspection to be at the Straits of Bab-el-Mandeb, the ports of the Red Sea, and Suez; and the imposition of especially rigorous quarantine upon pilgrims from India to Mecca and the Hedjaz, and upon those returning thence to Egypt and the Mediterranean ports.

Furthermore, quarantine found stronger advocacy than at Vienna. On arrival at European ports suspected vessels were to be considered entitled to free *pratique* only when inspection in the daytime by the medical officer of the port revealed that all needful precautions had been taken before sailing, and on the voyage, that no case of suspicious character had occurred on board, and that ten days at least had been spent *en route*. If this period had not elapsed since leaving port, a detention of twenty-four hours was required for observation, and the disinfection of soiled linen and other suspected personal effects. In the case of infected vessels, the port sanitary authority should cause the landing of the crew and passengers, the sick to be isolated and cared for, the healthy to be under observation, and the vessel, personal effects, and other dangerous articles to be disinfected. The period of observation was limited to five days, but if no case of cholera had occurred on board for ten days, the detention was reduced to twenty-four hours, as in the case of vessels merely suspected. Suspected vessels from Mediterranean ports were required to disembark their crew and passengers at a suitable place for observation, the period to be limited to from three to six days, including the time spent on the voyage. Infected vessels were to be treated similarly to those bringing the disease from India or the Red Sea.[1]

Quarantine has unfortunately been overshadowed by political considerations, and subserved the purpose of obstructing the commerce of a rival power far too well to allow it to be dispassionately judged in the cold, clear light of scientific evidence.

England has been assumed to oppose quarantine in port because her geographical position practically supplies her ships with a natural quarantine in passage, from the longer time taken to reach her shores, and she has been taunted with not being in earnest in her opposition, since her crown

[1] *Ref. Hdbk. Med. Sc.*

colonies of Gibraltar, Malta, and Cyprus impose severe quarantine restrictions. The reason these regulations continue to be imposed is mainly because these dependencies greatly rely upon neighbouring countries for their supplies and trade, and hence must yield to the pressure of their neighbours to prevent their supplies from being cut off.

Meanwhile the opinion of continental nations has been undergoing modification. At the International Congress of Hygiene, held in Paris during the exhibition of 1889, Dr. Proust, Inspector-General of the Sanitary Services of France, concluded a report on sanitation in seaport towns with these propositions :—that it is the duty of governments and municipalities to render ports healthy, that sanitary works for seaport towns are more necessary than for other towns, that it is only after such works that any notable reduction in zymotic and general death-rates takes place, and that it is only when ports present a refractory soil for the penetration of morbid exotic germs that the last restrictive measures upon shipping can be suppressed. In spite of the dubious signification of the last resolution, there was ample indication that quarantine was slowly but surely being whittled down to small proportions.

Dr. Proust repudiated any desire to revive the old quarantine methods. He stated that the term quarantine was open to misinterpretation, and its abolition was proposed at the Conference at Rome. Precautions need only be taken against plague, cholera, and yellow fever, as these diseases came from such a distance that precautions were possible. First, all consuls in the different distant ports could telegraph information; then the journey took from fifteen to twenty days, which was in itself a period of observation; and finally, most of the ships had to pass through the Suez Canal, where timely information could be obtained, and, if necessary, they might be detained before entering the Mediterranean. This detention was proposed at the Rome Conference, England and India alone voting against the proposal. If a ship had a disinfecting stove on board, an experienced surgeon, and no dangerous case had recently occurred, then it could be given free *pratique.* If there had been cases of cholera on board two or three days previously, then the ship should be detained. Practically,

on inquiry, it was found that this restriction would only have the effect of detaining four or five English vessels for four or five days in each year. England had already protested at the International Conference at Rome against the Suez Canal being treated otherwise than as an arm of the sea, and against her ships being detained in transit when not touching or landing passengers or goods.

Theoretically, the English contention that local sanitation is more important than quarantine was admitted, but practically no overture was made to abolish quarantine in European ports, but rather, in addition, to impose European quarantine upon vessels passing through the Suez Canal, so as to render quarantine in European ports less necessary whilst still retaining the power of imposing it at will; in other words, to make Suez the first quarantine port of defence, reserving the home ports for secondary defence, regardless of the fact that of every ten ships passing through the Canal nine are of a nationality that does not rely on quarantine, and that these must undergo the ordeal in order to satisfy the demands of the tenth.

There is no record of cholera having been traced back from Europe to India directly by the Suez Canal, although it may prevail in the Red Sea either on the Arabian or Egyptian shores, or on both. Immense and difficult as are the problems of sanitation in India, and although a vast deal remains to be done, the reports on sanitary measures in India are an earnest of the thorough manner in which insanitary conditions are being ameliorated, in spite of the serious hindrances imposed by the religions and prejudices of the natives. Amongst the English troops, the native troops, and the prisoners in the Bengal presidency, the cholera mortality that had averaged during the period 1853-72, 8.27, 2.57, and 7.94 per 1000 respectively, fell during the period 1873-87 to 3.01, 1.34, and 3.27 per 1000. M. Monod, Director of Public Hygiene in France, somewhat under-estimates the immensity of the task of applying sanitary measures in India, which is in no way comparable to that obtaining in England. The Native Passengers Act, making it compulsory to have a medical officer on board every ship carrying more than a hundred pilgrims, and the power to examine the passengers and remove infectious

cases, if efficiently carried out, must materially act in preventing the exportation of cholera.

Dr. Saleh Soubhy, Egyptian delegate to the Hedjaz during the pilgrimage of 1891, reported that out of 46,953 pilgrims of various nationalities to Mecca who arrived by sea, only 25,253 returned, the remaining 21,700, or 46 per cent., having died, chiefly of cholera. Of the six delegates present only Dr. Saleh Soubhy and his Ottoman colleague escaped with their lives. In 1890 the mortality was 33 per cent.

What is required in the Hedjaz, far more than preventing importation from India, is the carrying out at the pilgrimages to Mecca of sanitary measures as complete as those that have practically prevented outbreaks of cholera at the pilgrimages to the Hindoo shrines. The inadequate measures taken at the quarantine station at El Tor in the Red Sea have been clearly revealed by Dr. Paul Kaufmann, and it is here that a remedy requires to be applied.

Point by point the question has been fought out, to reduce the old method of exclusion in bulk by quarantine to the modern standpoint of medical inspection in detail. Opinion has reached accord so far as disembarkation and isolation of the sick, and disinfection and cleansing of the ship and personal effects, are measures to be adopted, and all that remains at issue is that of subjecting the healthy to the needless risks of detention. So much so, that in this country the term quarantine has its signification almost limited in application to the detention for observation of the healthy.

The International Sanitary Conference at Vienna, although rejecting the proposition to permit contaminated ships, bound direct to an English port, to pass through the Suez Canal under quarantine restrictions, but without detention, has accepted the propositions of the French delegates which reduce quarantine to the smallest proportions.

The French propositions class ships in three categories—healthy, suspected, and infected. Healthy ships to receive free *pratique*. Suspected ships to include those in which cholera was present at starting or on the voyage, an interval of eight days since the last case having elapsed upon arrival at Suez. This category to be divided into two sub-classes.

Ships provided with a surgeon and steam disinfecting apparatus to pass directly through the Suez Canal in quarantine. Ships not thus provided to be detained at Moses Wells until soiled linen, clothing, etc., be disinfected, and the sanitary conditions on board rendered satisfactory. Infected ships to include those having fresh cholera cases on board at the time of arrival or within eight days previously, and also to be divided into two sub-classes. Those not provided with a surgeon and steam disinfecting apparatus to remain in quarantine at Moses Wells for five days after the occurrence of the last case. The infected sick to be treated in hospital, and the other passengers to be isolated in groups; soiled linen, clothing, other articles in use, and the ship, to be disinfected, as well as such portion of the cargo as may be held to be infected. Those ships possessing a surgeon and steam disinfecting apparatus, and taking proper precautions, to be permitted to pass through the canal before the expiration of the five days, provided the sanitary authority so determine. As an illustration of how little obstruction to British shipping interests this would cause, the number of vessels passing through the canal was quoted by the French delegates as follows:—

Year.	Total Number passing through.	Suspected.	Infected.
1885	3100	13	0
1886	3100	6	2
1887	3137	4	0
1888	3440	8	0
1889	3425	9	0
1890	3389	1	0
1891	—	7	0

An analysis of the processes involved in the present form of quarantine will also serve to explain the alternative defensive measures adopted by England. The first step necessary is the compulsory declaration by the captains of vessels of the cases of infectious disease present. In maritime quarantine this is generally restricted to plague, cholera, and yellow fever. In England compulsory

declaration or notification has now been extended so as to be applicable not only to sea-going passengers but to almost the whole nation, and the number of diseases compulsorily notifiable includes almost all the more dangerous infectious diseases, exotic and endemic. The exception of plague and yellow fever must be noted. These two diseases are still under the old quarantine acts. They are rarely brought to this country, and although from time to time a case of yellow fever arrives in a home port, neither of these diseases are likely to obtain a foothold. Still, this is perhaps a greater reason for treating these diseases administratively in a similar manner to cholera, and transferring their control from the Privy Council, under the Quarantine Acts, to the Local Government Board and Port Sanitary Authorities, under the Public Health Acts. This will be the ultimate drift of legislation so soon as the government is fully alive to the anomaly. The second step is isolation of the infectious sick arriving by sea, and in this country all infectious sick, whether on sea or on land, when under conditions dangerous to others, and without the means of proper isolation, are removed to special hospitals for infectious diseases. The third step is that of disinfection and purification, now not restricted to sea passengers and to ports, but practised universally by land and sea more or less effectually, according to methods and appliances. The fourth step is the observation and detention of the healthy, the true contentious point in quarantine, and practically now the only essential one. When it is removed, quarantine will exist no longer.

CHAPTER II.

THE NOTIFICATION OF DISEASE.

THE old quarantine system was based upon the compulsory declaration of infectious disease in the bill of health, and the modern form of compulsory notification is but the ultimate outcome of the abolition of the quarantine system advocated by the General Board of Health forty years ago. The substitution of medical inspection, and the departure of healthy persons from infected ships to their destination, finds its complement in the extension of compulsory notification from ports of arrival to the country generally, an extension receiving additional impulse from the growth of intercommunication and the rapidity of transit which have broken down cordons and quarantines. Although compulsory notification is the corollary of the fundamental change of method, it did not follow directly upon it, but rather as the logical conclusion of the system that displaced it.

The laying of the foundations of that system commenced with the ushering in of the reign of Queen Victoria, Edwin Chadwick, Neil Arnott, Kay, and Southwood Smith leading the van by their inquiries into preventable disease, with Graham and Farr organising the registration of the causes of deaths. The advances in medical education, the enlightenment of the legislature by numerous official inquiries, the passing of the Public Health Act of 1848, and the creation of the General Board of Health, commenced to build up the system. The appointment of Medical Officers of Health, of Duncan to Liverpool, and especially of John Simon to the city of London, the creation of a Medical Department of the Privy Council, and later of the Local

Government Board, prepared the way for improved sanitary legislation. Later enactments perfected and consolidated the system of local government, whereby the whole country was placed under the control of Sanitary Authorities, Medical Officers of Health, and Sanitary Inspectors. Although health officers in inlying districts were but the complement to health officers in ports, their appointment originated mainly in efforts to provide for local sanitation; but the principle of dealing with imported infection in detail in a similar manner, and together with indigenous infection, was that which guided the policy of English sanitarians in building up a second line of defence against imported disease.

The registration of the causes of deaths afforded some guide as to the sanitary condition of districts, but was inadequate for the immediate purpose of controlling the spread of infectious diseases, for which purpose the notification of such diseases was an obvious necessity. The demand became more imperative as time wore on and exposed the inefficient powers of the sanitary authorities for coping with contagion. Death-returns only gave information of infectious disease at its termination, and only when fatal, so that but a proportion of infectious cases were thus ascertained, and then at too late a period.

The advantages derivable from compulsory notification may be summarised as follows:—

1. Timely and entire information of *all* cases of the diseases notifiable, their nature and location.

2. Power of preventing the spread of infection.

   a. By enforcing proper isolation within the house and preventing exposure without, and by encouraging the treatment of non-isolated cases in hospitals provided for the purpose.

   b. By enforcing the disinfection of persons and personal effects, and of dwellings and their contents.

   c. By vaccinating those in contact with small-pox cases.

   d. In case of death, by taking proper precautions for the disposal of the body.

   e. By preventing the attendance of infected children at school, and of infected adults at workshops, offices, etc.

f. By protecting clothing and fomites generally from being infected in domestic workplaces, laundries, etc.

3. Means of ascertaining the cause of outbreaks of disease.

a. By investigating the sanitary condition of localities, premises, and houses.

b. Inquiring into the health of households and the associations of the occupiers.

c. By inquiring into sources of water, milk, and food supplies.

d. By inquiring into the school, workshop, office, etc., attended, or laundry used.

e. By ascertaining the effects of these upon a number of scattered individuals and bringing the facts to a focus, both in tabular form and upon spot maps.

4. Furnishing the data for statistical records of the prevalence and virulence of diseases, and of the variations to which they are subject.

a. The number of persons attacked by notifiable diseases in given areas.

b. The number attacked during given seasons and periods.

c. The age and sex of those attacked.

d. From these may be calculated the mortality ratios according to population, age, sex, and season.

e. In conjunction with the returns of deaths, the case-fatality of each disease according to age, sex, and season may also be calculated.

f. It is thus possible to record the variations of the prevalence and fatality of diseases as graphically as meteorological variations, by means of charts and curve-lines, either daily or for periods of any length of time.

Notification being only a means to an end, however, it must form part of an organisation for the control and prevention of infectious diseases, and its value will be in proportion to the efficiency of the public health service in existence in a locality, which may be summed up as—a willing and educated sanitary authority, a trained medical officer of health, a skilled surveyor and engineer, competent sanitary

inspectors, the prompt and efficient execution of prophylactic and sanitary measures, proper machinery for controlling infectious diseases, means for disinfection, hospital accommodation, etc.

The objections that have been raised against compulsory notification are mainly (1) that it is an interference with the liberty of the subject to compel the notification or disclosure to a public authority of the presence of infectious disease within the household; (2) that it is an interference between the medical attendant and his patient, causing a breach of professional confidence by compelling the nature of the infectious disease to be compulsorily certified; (3) that it must lead to concealment, to the avoidance of the services of regular practitioners, to the encouragement of uninstructed purveyors of drugs, and the neglect of the treatment of the infectious sick.

The right of the liberty of the subject has given way to the right of the freedom of the community from communicable disease; the lesser has rapidly yielded to the greater. The citizen had no wish to notify the presence of infectious disease himself, but actually had an aversion to do that which he knew his neighbour probably would not do; on the other hand, he was particularly anxious to protect himself against his neighbour's infection, and desired rather to impose compulsion upon him; consequently a general imposition falls lightly on the individual who is conscious that he is subject to the same equal treatment as his fellow-citizens, and that for his single notice given to the sanitary authority hundreds will be received from his neighbours.

It has been urged that the medical attendant is the proper adviser and supervisor of both the treatment of an infectious patient, and of the precautionary measures necessary to prevent the spread of the disease, and that he would voluntarily report to the sanitary authority those cases in which interference for the protection of the public was necessary. It must be borne in mind that the private medical attendant's first duty is to his patient, the next to the patient's family, but the public is his last concern, while the public health officer's duties are in the reverse order. Furthermore, amongst the poor especially, medical attendance is often restricted, for pecuniary reasons, to a brief

period, and ceases with the early and acute stage of disease, the subsequent, but still infectious stages running their course without any medical supervision, or the adoption of any precautionary measures.

Voluntary notification, or rather certification, has been amply tried and failed. The action of the medical attendant must necessarily conform more or less to the wishes of the patient, and of the patient's family; a voluntary system must therefore depend not upon the medical profession, but upon the wishes of individual members of the community.

To object to notification on the ground of the absence of suitable hospital accommodation for infectious diseases is equally as inconsequential as to object to providing hospital accommodation because of the absence of notification. Public authorities are never too ready to incur the expenditure necessary for providing hospitals, and notification is the very impetus required. It brings to light the number of cases of zymotic disease improperly isolated, and demonstrates by facts and figures, so requisite to convince public authorities, the necessity for hospital provision. The same applies to means for disinfection, and for carrying out sanitary measures generally. On the other hand, costly sanitary organisations and hospitals are deprived of their main utility in protecting the public health by the absence of notification. Dr. Alfred Hill, in a paper on "Notification," read at the International Health Exhibition in 1884, very cogently put the relative values of notification and hospital accommodation:—"The absence of notification, full and complete, has a relation to the extent and cost of hospital accommodation which is worthy of notice. For instance, supposing every case of disease be reported as soon as made out, the first cases would receive proper attention and isolation, the disease would be nipped in the bud, and a very small hospital would suffice; but if, on the other hand, first cases are not reported, the stamping out process fails, the disease rapidly extends and becomes epidemic, and then the most gigantic hospital fails to meet its demands. This relation between notification and cost of hospital accommodation, without regard to other considerations, seems to me a matter of the greatest importance; and the fact should not be lost sight

of, that the main value of a hospital for infectious diseases is to treat first cases and prevent epidemics, and not to treat thousands of cases which might with proper care have been prevented."

The principle of compulsory notification being justifiable, the question then arises: What shall be the mode of procedure? If general compulsion be imposed, it becomes a duty of citizenship, and falls firstly upon the natural guardian of the patient to notify the presence of infectious disease to the sanitary authority, for the purpose of enabling such measures to be taken as may be necessary for the protection of the public.

The notification would be of little value without a medical certificate of the nature of the infectious disease; hence, under any system adopted, it is necessary to impose compulsory certification upon the medical attendant. The difference of opinion that arises thereupon is whether the certificate should be delivered to the guardian of the patient, imposing upon that person the duty of delivering it to the officer of the sanitary authority, or whether it should be transmitted by the medical attendant direct to that officer. In the former case, the notice and the certificate would be received from the same individual; in the latter, from different individuals. The former has been termed the *single*, and the latter the *dual* system of notification.

In the registration of deaths the *single* system prevails in this country, and the certificate of the cause of death is delivered to the person who notifies the death to the Registrar, and at the same time delivers the medical certificate to him. This mode of procedure was adopted in deference to the medical opinion prevailing at the time of the passing of the Registration of Births and Deaths Act. That it is the less desirable mode of procedure of the two is evidenced by the fact that the more recent Infectious Disease Notification Act has adopted in preference the dual system, the medical attendant being required to transmit forthwith the certificate of the nature of the disease direct to the medical officer of health, the guardian of the patient being also required to notify the presence of infectious disease. Though in practice the person

liable to notify commonly omits to do so, assuming that the medical certificate becomes also essentially a notice, nevertheless he is not thereby exonerated from his liability as a citizen to give due notice in accordance with the Act.

The Edinburgh Municipal and Police Act of 1879 placed solely on the medical attendant the onus of certifying within twenty-four hours. Palmberg[1] states that in Brussels, by a decree as far back as 1818, increased in vigour by a further decree of 1824, the medical attendant was required compulsorily to certify infectious diseases to the municipal authorities. In Austria and in Sweden the responsibility is thrown upon the medical attendant. In Finland the guardian of the patient is called upon to notify, but in the city of Helsingfors it is also the duty of the medical attendant. In Holland and throughout Germany the dual system is in vogue. France has steadily opposed the introduction of notification, although opinion appears now to be gradually veering round, but it must be remembered that the policy of France has hitherto been to oppose every sanitary measure that failed to support quarantine, notification being possibly regarded as an undermining influence.

That the dual system is more correct in theory, and has proved simple and expeditious in practice, can scarcely be denied after the experience gained in a gradually increasing number of towns (commencing with Bolton in 1878), only three cf which adopted the *single* system—namely, Bradford, Norwich, and Nottingham. Upon this experience the Act of 1889 is based, and although its adoption is only permissive, with the exception of London, where it came into force two months after becoming law, yet it is now in force in districts containing five-sixths of the population of England and Wales. The diseases scheduled in the Act are cholera, small-pox, typhus, enteric, continued, relapsing, and puerperal fevers, scarlatina, diphtheria, membranous croup, and erysipelas; and a sanitary authority has power to add to these by carrying out certain legal formalities.

Some doubt has been cast upon the value of notifying

[1] *Traité de l'Hygiène Publique.*

erysipelas, a certain proportion of trivial cases being reported. It would be difficult to determine what cases should or should not be notified, or to differentiate between major and minor, traumatic and idiopathic erysipelas. The choice lies only between wholly excluding or including the disease in the list. Forcible reasons exist for notifying it; in large institutions it occasionally assumes formidable epidemic proportions, and sporadic cases are always a source of danger. The Local Government Board urges that it is an infectious disease, communicable to others, and of especial danger to lying-in women, vaccinated children, in surgical operations, and to wounds generally. Altogether the advantages of notifying it overbalance the disadvantages.

Much difference of opinion exists as to the desirability of adding measles to the list. The reasons advanced in favour are numerous. Measles causes a larger number of deaths than any other zymotic disease, excepting whooping cough and diarrhœa; it is highly infectious, and the infectiousness continues after the appearance of the rash and until the branny desquamation ceases. It is largely spread through the medium of schools; it is too late to close schools after the disease has obtained a hold. The protection of schools and the prevention of epidemics would be furthered by notification, enabling infected children to be detained at home, and by the opportunity afforded to send printed instructions for dealing with the disease, and the precautions to be taken to prevent its spread. The high death-rate is largely due to inadequate treatment and insanitary surroundings; death from the disease in the families of the better classes is uncommon, whereas it is more frequent amongst the poor in crowded dwellings. The provision of isolation in hospital, which should follow upon notification, would, besides checking the spread of the disease, give the sufferers a better chance of recovery under improved conditions; and the disinfection and general cleansing that should follow upon removal to hospital would tend to reduce the virulence of the disease, when threatening to assume epidemic proportions. The arguments brought against the notification of measles are equally cogent. The advantages to the poor of treatment

in hospital apply more or less to all diseases, and notification would be of little value unless provision were made of isolation in hospital, and disinfection and cleansing of the infected dwelling after all cases. The disease mainly prevails amongst children before school-age, the maximum mortality occurring during the second year, and rapidly diminishing through childhood till it becomes insignificant (this is probably due to the immunity secured), and, further, the disease becomes more or less epidemic every other year.

The case-fatality is not high as a rule; it is generally estimated as 10 or 12 per cent. of the attacks; but the experience of Edinburgh, where measles is notified, gives a maximum case-fatality of 5.9 per cent. of notified cases, and a minimum of 1.5, the average being 3.1 per cent. during ten years. From these proportions, and the number of deaths, it is an easy matter to calculate the total number of cases that would require to be dealt with.

It is infectious before the rash appears, and therefore before diagnosis is confirmed, if medical opinion be sought; but in the majority of cases, or probably in at least one-half, medical advice is not sought. There would therefore be some difficulty in obtaining medical certificates. Notification by the parent of the infant or child, *if given,* would necessitate a compulsory medical visit, which by many among the poor would be resented as a reflection upon their capacity to nurse a simple ailment without the enforcement of isolation and disinfection, and all the circumstances attending it, and lead to concealment where possible. It has been urged that it has not yet been demonstrated that measles follows the same law as scarlet fever, and that there is no reason for assuming that with increased age susceptibility to attack and to fatality diminishes. And lastly, it has been urged that the result would not justify the large expenditure.

Dr. Harvey Littlejohn, in his account of ten years' compulsory notification in Edinburgh, expresses the opinion that "in a large town with a susceptible population, and hospital accommodation necessarily limited when compared with the requirements of an outbreak of measles, notification as a means of checking the disease is practically useless." He points out that whereas during one month

only a few cases may be reported, during the next they may mount up to hundreds, so highly infectious is the disease. But he admits that it is probable that if, when there were only a few cases in the town, it were possible to compel every case to undergo strict isolation, to a great extent such epidemics might be avoided. The number of cases of measles isolated in hospital during the ten years in Edinburgh appears to have been infinitesimally small, and what amount of disinfection and cleansing were practised after the disease does not appear, the authority only acting when so desired. Further, it does not appear as if suspected children, or children coming from an infected house, were rigidly excluded from schools, or that any measures were taken to prevent exposure out of school; these are most important points, that must materially modify any strong opinion against the notification of measles.

In Vienna compulsory notification is also applied to some other diseases besides those already mentioned—dysentery, ophthalmia, whooping cough, hydrophobia, and trichinosis being included. In this country, notification being regarded as a means to an end, the end being isolation, disinfection, and sanitation, it is difficult to find their application in dysentery and ophthalmia, except on a domestic scale by individual treatment, although possibly whooping cough might be somewhat amenable to public control. Hydrophobia and trichinosis are diseases that might well be included amongst notifiable diseases; they are very rare and very fatal, and being communicated from lower animals, would act as guides to the control of the communicable diseases of animals.

Mere notification without defensive measures and sanitation can have no effect in diminishing communicable diseases. For this reason, little hope has been entertained of deriving any practical results from the notification of influenza. The value of notification increases in proportion to the extent to which it is utilised for the purpose of suppression and prevention. The compilation of figures for an impartial judgment of the practical effects of notification must therefore comprise statements of the number of cases notified, the proportion isolated at home and in hospital, the number after which disinfection has been carried out

in an efficient manner, and in which sanitary remedial measures have been adopted, together with the respective mortalities; and unless these are all taken into consideration, and for a series of years, the results may be misleading. The measures taken in surrounding districts must also be taken into account.

Notification depends for its efficient working—firstly, upon a conscientious public that has learnt to estimate the value of health, to appreciate the facilities offered for its protection, to regard infectious disease as a misfortune to be met and combated, not as a disgrace to be punished, and refraining from concealment in the interests of the patient and the family as well as of the community. Secondly, upon an educated public seeking skilled medical advice for the treatment of all cases of sickness and disease, the affluent resorting to family medical attendants, the indigent to the medical officers of public institutions, or to the district medical officers provided by the guardians of the poor at the expense of the State, no stigma attaching to eleemosynary medical relief. Thirdly, upon an educated medical profession skilled in the knowledge of disease, and specially trained in the diagnosis of communicable disease, clinical instruction in infectious diseases being made compulsory, as part of the medical curriculum. Fourthly, upon a standard nomenclature with clearly defined terms for the diseases notifiable; for instance, "puerperal fever" is unsatisfactory in this respect, as it embraces a variety of more or less incomparable terms expressive of various puerperal conditions, and "measles" may be held to include German measles or not. Hence, it is preferable to have more rather than fewer synonyms of diseases scheduled for notification.

As an argument against notification, an extraordinary paragraph in a volume presented to the International Congress of Hygiene and Demography, 1891, entitled, *Denmark: its Medical Organisation*, has been frequently quoted. It occurs on page 426, and runs, "It is remarkable —considering the advance of public as well as of private hygiene in Denmark during the last thirty years—that the mortality of those periods of age most liable to epidemic diseases, against which hygiene mostly directs its efforts, is not influenced by sanitary improvements. Maturity and

old age have gained considerably in vitality during the last fifty years." This statement is based on statistics terminating in 1884. Although Denmark appears to have enforced for many years a system of weekly reports of sickness from district medical officers, it does not appear to have instituted a system of immediate notification of infectious diseases until the Act of April, 1880. Sanitary inspectors, or any officers corresponding to them, do not appear to exist, and as to sanitation, it is in a state "essentially corresponding to the conditions in England before the Public Health Act, 1875." Under such conditions Denmark can scarcely be held to represent the effects of notification properly carried out.

As notification is a means to an end, its effects cannot be fairly judged in the absence of measures that should follow upon it. It is sufficient to glance at the table of the annual death-rates from the principal zymotic diseases for consecutive years in the Annual Reports of the Registrar-General to verify the fact that the mortality from these diseases, preventable by isolation in hospital, by disinfection, and by domestic sanitation, has been for years past steadily on the decline. With the increase in the number of hospitals for infectious diseases, and the number of cases isolated, the advances in methods of disinfection, and the improvements in domestic sanitation, it can but be assumed that the mortality must continue on the decline, to which notification must contribute by extending the application of these measures.

As upon the receipt of the medical certificate by the sanitary authority, registration takes place, practically there now exists in this country, as well as a registration of deaths, a registration of sickness from certain scheduled infectious diseases. At this point the analogy ceases, for the sickness returns, unlike the death-rate returns, are not compiled into county returns, except for certain large towns and cities that are themselves counties.

In August 1888 Dr. Tatham, in a paper read before the British Medical Association, advocated the national registration of infectious diseases, and described how, following the previous attempts of Dr. B. W. Richardson, F.R.S., and Dr. A. Ransome, F.R.S., in the registration of sickness,

he had, in co-operation with thirty-two other medical officers of health of towns that had adopted compulsory notification, initiated a system of tabulating and circulating a weekly compilation. Having started the movement, it was introduced to the notice of the Local Government Board, and has since been continued on this scale.

In the meanwhile the local organisation of registration remains undeveloped. The first step necessary to build up a system of national registration must be for each sanitary authority to furnish a return of notifications to each of the adjoining authorities, and to the County Council. In this manner mutual protection would be secured, and the county authority would be in possession of the knowledge of the prevalence of disease in the area. In London this is practically carried out by the returns furnished daily by the sanitary authorities to the Metropolitan Asylums Board. It only requires supplementing by the sanitary authorities furnishing copies of this return to the contiguous sanitary authorities. The next step must be for the county authority to condense these returns, and supply them weekly to the surrounding counties and to the Local Government Board. In the metropolis the Asylums Board makes this weekly compilation, which is supplied to the various Sanitary Authorities and to the County Council.

This weekly compilation would facilitate the next step, the Local Government Board, as the Central Authority, further condensing the returns and publishing them in a form on the lines of the Registrar-General's weekly returns of deaths, constituting a complete system of National Registration. These national returns, if pushed a step further, would form the basis of an International Registration of infectious disease by exchange with other nations. Thus, with facility, would be reached, step by step, an organisation similar to that suggested at the International Sanitary Conference at Washington, and again at Vienna, but avoiding the establishment of an International Board of Health.

International Registration is a desirable object to be attained, but an International Board of Health, for the purpose of formulating and enforcing hard and fast rules for endemic diseases, might lead to the imposition of restrictions

carried by a less enlightened majority, and enforced in a stereotyped manner, regardless of local exigencies.

Concealment is a point that must be borne in mind in reference to notification, and for this reason it would be useless to apply compulsory notification to venereal diseases. The compulsory examination of prostitutes is practically an attempt to circumvent concealment, and has given rise to the question—Why not also examine the men consorting with them, if the object be the prevention of the spread of disease? It has also been urged that compulsory examination, and the registration that must precede it, increase clandestine prostitution, and defeat the object aimed at—namely, the suppression of disease.

The prevention of venereal diseases includes an ethico-moral as well as a public health question, and the former overshadows the latter. But it must be admitted that whenever the State places insuperable restrictions on marriage, it must be held gravely responsible for the consequences; this applies especially to the military and naval services.

The operation of the Contagious Diseases Act, which was passed in 1864, amended in 1866 and 1869, inquired into by a Royal Commission in 1870, and finally repealed in 1884, is lucidly set forth in the paper of Inspector-General Lawson, read before the Royal Statistical Society in January 1891, the conclusions come to being that the influence of the Acts materially diminished the mortality from syphilis, not only in the immediate localities where they were enforced, but to a large distance around them, and that since the repeal of the Acts the diseases have reverted to the extent and severity that existed before their passing.

The State of Massachusetts has recently passed a law for the detention of certain persons affected with syphilis,[1] in which it is enacted that persons suffering from syphilis, and being inmates of any correctional or administrative institution, such as a house of correction, a penitentiary, or a workhouse, shall be placed under medical treatment, and be isolated until the medical attendant shall consider further isolation unnecessary; and if at the date of discharge of

[1] *Boston Med. and Surg. Jour.*, 2nd July, 1891.

a person syphilitic symptoms are still present, and likely to prove a public danger, compulsory detention may be put in force to retain the infected person until such a time as dangerous symptoms have been pronounced to be no longer present.

But this topic is fraught with so many difficulties, and so many social and moral questions are brought to bear upon it, that there is little likelihood of reaching any very definite conclusions at present. Its introduction here is appropriate, as demonstrating that the compulsory notification of diseases has limits.

CHAPTER III.

ISOLATION.

In the presence of epidemics the ancients resorted to flight as their only safeguard, and we find Ezekiel saying, "Those who are in the city hunger and plague will devour, and those who flee shall be saved;" in this manner the depopulation, ruin, and disappearance of many of the cities of antiquity doubtless came to pass.

Approaching modern times, the spirit of combating rather than fleeing infection appears, and it assumes the form of isolation. Isolation, as a generic term for the prevention of the spread of infection, leads to much confusion from the absence of discrimination between the two methods of isolation. The two methods may be concisely described as those of *exclusion* and *seclusion.*

Wholesale exclusion was the principle adopted under the old quarantine and cordon system, already described, to protect a country from invasion by epidemics of oriental plague, Asiatic cholera, and yellow fever, the protection of single towns by similar means being a restricted application of the same method. Wholesale seclusion, by which ships in quarantine and towns within cordons were sequestered or invested, also formed part of the system. These are now displaced by exclusion and seclusion in detail.

Exclusion finds its present application in towns in rejecting or forbidding infected persons, or persons living in direct contact with them, attending or frequenting *crèches*, schools, workshops, factories, offices, and other private or semi-private places. This form of exclusion is practised voluntarily, and in this country is not enforced by law. It is probably assumed that in order to reach the places mentioned

it is necessary to incur exposure on the public way, or in a public conveyance, which is forbidden by law. It may be necessary, but the law does not specify that the proof of the finding of an infected person on premises other than those in which the person has been residing is proof of exposure, although there is little doubt but that there must have been exposure, except the transfer have taken place in a special conveyance. It is therefore necessary to prove exposure in case of an offence; this is not always possible: nor is the exposure in the public street quite so serious a matter as the intrusion of an infected person upon private premises, or within buildings or rooms inhabited by others, and commingling with the healthy occupants. Yet this is not a legal offence.

There is a strong contrast in the manner in which personal infection is spread in non-residential and residential schools. In non-residential schools children from various households meet at a centre, become infected, and returning, distribute the infection broadcast, closure being resorted to for the purpose of checking its spread. In residential schools, on the other hand, the infection is more or less confined to the limits of the school, and is only distributed beyond upon the disbandment of the pupils. Hence, it is interesting to note that opposite results may follow the similar process of closing a school, in the two cases, unless extreme precautions are taken.

Residential schools, like other residential institutions, protect themselves from admitting infected scholars from without by requiring certificates of freedom from infection, or from contact with infection, upon admission; and, when invaded, from the spread of infection within, by isolation in proper quarters. Non-residential schools, where the attendance is daily, do not admit of the application of measures of protection in this form, and are dependent upon school-teachers immediately excluding from attendance children suffering from infectious disease, or being members of an infected family or household. This exclusion can only be enforced by the teacher or manager being informed by the parents or by the sanitary authority of the cases of infectious disease occurring amongst the scholars. Compulsory notification is therefore a valuable protection to

schools. If exclusion fails, and infection reaches a school not directly, but indirectly by the commingling of infected with healthy children beyond the precincts of the school, it points to the absence of proper seclusion of the infected children at home or in hospital, and it is only when seclusion as well as exclusion fail to prevent an epidemic in a school that dissolution or closure of the school is justifiable. Defects of internal condition, structure, or site, liable to lead to such a result, are naturally also included in such justification. The memorandum issued in December 1890 by the chief medical officer of the Local Government Board, explains in a very full and lucid manner the measures necessary to be taken in this direction for the protection of "public elementary schools" by sanitary authorities, and Article 88 of the Code of Regulations, approved by the Lords of the Committee of Council on Education, prescribes as a condition of the annual parliamentary grant to a public elementary school, that the managers must at once comply with any notice of the sanitary authority as to the exclusion of scholars or the closure of schools. Thus indirect pressure effects that of which sanitary law takes little cognisance.

Legally, exclusion has been narrowed down to exclusion from public ways, public places, and public conveyances. The law prohibits wilful exposure of a person suffering from a dangerous infectious disease, without proper precautions, in a street, public place, shop, or inn, and also lending, selling, transmitting, removing, or exposing, without previous disinfection, any infected articles. It also prohibits (in London) the conveyance in a public vehicle of a person suffering from a dangerous infectious disease, and empowers the sanitary or local authority to provide special vehicles for this purpose.

The complement to exclusion is seclusion, and the prohibition of exposure in the public way is intended to enforce the seclusion of an infected person in the house. In some countries this seclusion is further secured by means of a placard attached to the front door or window, and bearing upon it the words "Infectious Disease," or the name of the disease from which an inmate is suffering. In towns, we must distinguish between a house occupied

by only one family and that occupied by more than one family, or several dwellings in one house, as there is a considerable difference in the amount of risk incurred under the two conditions. It may be possible, with care, to isolate an infectious case, and to conscientiously carry out the necessary precautions in the former, whereas in the latter this can only, in most cases, be accomplished with difficulty.

The risk of infection increases in direct proportion to the greater number of dwellings in a house. It also varies in proportion to the amount of separation that exists between the several dwellings. It is much greater, so far as other occupants of the same house are concerned, in a house constructed originally for one family, but let out to several occupants—a made-down house—than in a house constructed specially for occupation by several families, and in which each dwelling is in itself complete, and separate from the rest of the building. It becomes practically impossible to procure proper isolation, so far as other occupants of the same dwelling are concerned, in poor families in occupation of single rooms, or of two rooms, which are usually adjoining and generally open into each other. This applies equally to made-down houses and to specially constructed blocks, for in the latter, economy of space promotes their construction in such a manner that the rooms lead out one from the other.

A further difficulty presents itself, amongst the poor especially, in the curtailment of medical attendance for economical reasons. An infectious case may be just sufficiently isolated or secluded at home, and be surrounded by such precautions as to disarm any accusation of jeopardising the health of others during the acute stage of the disease, under the care of the medical attendant. With the cessation of medical attendance precautions may be neglected, and possibly before any intervention can take place the infected person may have issued from seclusion, and have spread infection to other occupiers of the house, all equally as ignorant or neglectful of the risk involved. If the house be not quitted there is no exposure, in a legal sense, since this must take place in public, and it might be difficult to prove, as the law requires, that the infected

person was "without proper lodging or accommodation." An occupant of the house desiring to prevent his family from being infected by the absence of proper control over an infected person in the same house, would doubtless be able to give information and evidence that the infected person was without *proper restraint*, but the law does not provide for this except it be embraced by "proper accommodation." Hence to encourage the nursing of infectious patients at home in the crowded dwellings of the poor by visiting nurses, need only be mentioned to be condemned.

A still further difficulty in preventing the spread of infection presents itself in the use to which the dwelling or part of the dwelling may be put, as a domestic workshop or store. Tailoring, dressmaking, or the making up of other kinds of clothing, or the handling of various stuff materials, or laundry work may be carried on either in the same room, or in a room adjoining that in which a person suffering from infectious disease may be lying or moving about, or even working to keep body and soul together. Various kinds of food, as milk, bread, etc., may be stored, or prepared in shops, or places forming part of, or adjoining dwelling-rooms harbouring infection.

The varying amount of risk incurred in the different infectious diseases under diverse circumstances must be estimated in each particular case as it occurs. Three methods for preventing the spread of infection by seclusion are available: (1.) To seclude the dwelling and the occupants by warning off communication, the method adopted in countries where "placarding" is resorted to for the purpose of placing the dwelling in quarantine. (2.) The healthy occupants may betake themselves elsewhere in order to avoid infection; this is a voluntary act sometimes resorted to in houses occupied by only one family. (3.) The removal of the infectious patient to other quarters, which may be private or public places set apart for the purpose, temporarily or permanently. Private individuals occasionally avail themselves of the use of private premises and of homes extemporised, or permanently set apart for the purpose of nursing infectious cases, and most private and public institutions provide special places for the use of their in-

mates. Public hospitals for the reception of persons suffering from certain infectious diseases are provided in most large towns and in many rural districts, and the suppression of infectious diseases depends mainly upon this provision. Over four hundred sanitary authorities in England have already provided special hospitals, at the cost of about half a million of money.

In the early days of quarantine on sea-boards, the lazarets in a rough and uncared-for manner answered the purpose of hospitals according to the prevalent ideas of the period. Inland, pest-houses were provided later for a similar purpose, and the measures controlling them were rigorous in the extreme. In an Act of the seventh year of George I., 1710, it was provided that in case an infected person quarantined in a pest-house shall actually escape out of such house, lazaret, or other place, where he shall be so placed for performance of quarantine, before he shall have fully performed the same, he shall be adjudged guilty of felony, and shall suffer death as a felon without benefit of clergy. The recent provision in the London Public Health Act, that a person in a hospital suffering from infectious disease may be detained by order of a justice for the purpose of preventing the spread of the disease, is by comparison the mildest of measures. The *Lancet* (May 3rd, 1891) mentions also a punishment of the same early date, found in the accounts of a Huntingdonshire village constable: "Paid Thomas Hawkins fur whipping 2 persons yt had small-pox, 8d." But infectious diseases, excepting plague, its congener typhus, and small-pox, did not find their way to the pest-houses. The general hospitals for nursing the sick received infectious as well as all other classes of diseases.

It was not until the commencement of the present century that separate wards and hospitals for the treatment of fever were established. Chester, Liverpool, Manchester, Norwich, Hull, Dublin, Cork, Waterford, and London first introduced into hospitals the isolation system which received its impulse from Haygarth of Chester, Stanger of London, Clark of Newcastle, and Ferriar of Manchester, in the first few years of this century.

It was feared that the aggregation would increase the

virulence of the diseases, but Murchison found no evidence to show that in a well-ventilated fever hospital the mortality from continued fevers was greater than in a general hospital, and the experience of the Metropolitan Asylum Board has fully confirmed this. It is now well recognised that the successful treatment of infectious cases is dependent upon the amount of floor space, cubic space, and ventilation, and the seclusion of each particular disease in a special ward or block. This rigid seclusion is most necessary for small-pox, and will be again referred to; it applies also strongly to all diseases communicable by the exhalations, but with less force to diseases communicated by the excreta, as enteric fever, which is most dependent upon the treatment of the dejecta.

The effects of the aggregation of communicable diseases in hospitals upon the surrounding neighbourhood, from the experience of the London Fever Hospital, shows that under proper precautions little or no risk of the spread of the infectious diseases takes place. Small-pox is a notable exception, and the comprehensive reports of Mr. W. H. Power upon the Fulham Small-pox Hospital, in the tenth and fourteenth Reports of the Medical Officer to the Government Board, clearly demonstrate the amount of risk run by the surrounding neighbourhood. The marked fall in the mortality from small-pox in the Metropolis since the transference of the small-pox hospitals down the river Thames to Darenth fully confirms the conclusions of Power.

The mortality in the Metropolis from the infectious diseases admitted to the Asylums Board's hospitals has steadily declined in recent years, with the exception of that from diphtheria,[1] but the period (three years) since which this disease has been admitted is too short to permit of any reliable conclusions, especially as the cause of the spread of this disease is as yet little understood; although, as Dr. Thorne Thorne has pointed out, its extension is coincident with the increase in the number of elementary schools under the Education Acts. The case-fatality of diphtheria admitted has, nevertheless, during the last three years, fallen from 59.3 to 33.7 per cent.

Dr. J. B. Russell, in commenting upon the effects of

[1] *Report of Statistical Committee*, 1890.

notification and isolation in Glasgow upon scarlet fever,[1] has given the figures for corresponding periods as follows :—

Glasgow.	Cases.			Deaths		
Period.	Hosp.	Home.	Total.	Hosp.	Home.	Total.
18 weeks, 1880	416	829	1245	52	161	213
18 weeks, 1890	697	434	1131	24	15	39

The practical outcome was that although the pressure on the hospital was much greater in 1890 than in 1880, only 39 lives were lost as compared with 213, and he concluded that "the evidence of the success of prevention, in so far as isolation is concerned, is and may be formulated as an increasing proportion isolated of a diminishing total quantity of infectious disease existing. The acme of this success will be the largest proportion isolated of the smallest quantity of disease existing."

The increasing favour with which treatment in hospital is regarded by the public is well shown in the Metropolis by the increasing number of cases of infectious disease admitted to the hospitals of the Metropolitan Asylums Board. Within the last five years the numbers have quadrupled, rising from 2,197 in 1886 to 8,334 in 1890. One-third of the total number of notified cases of infectious diseases legally admissible[2] were treated in the Board's hospitals during 1890, and of scarlet fever alone 42.6 per cent. were so isolated. In many municipal towns a far higher proportion of notified cases are isolated in hospital; in 1891, in Brighton, 70 per cent. of scarlet fever cases are reported by Dr. Newsholme to have been so isolated.

Hospitals for communicable diseases may require to be provided under varying conditions. For epidemics of exotic diseases, as in the case of Asiatic cholera, special temporary provision must be made in the midst of each infected area, for cholera is a rapid disease, and the sufferers will not bear distant transit; temporary refuges must also be provided for families removed from infected houses,

[1] *Lancet*, November 20th, 1890.

[2] The diseases admissible are the fevers, small-pox, and diphtheria.

from which the patients cannot be removed. In indigenous infectious diseases, by means of permanent hospitals, the prevention of these diseases reaching epidemic proportions is more or less secured. Whilst by the temporary extension of the accommodation of permanent hospitals, or by temporary special provision, epidemic outbreaks of indigenous diseases may be combated with more or less success. The whole drift of hospital provision is towards the prevention of epidemics by the isolation of first cases of infectious disease, the improvement of the treatment of the cases admitted upon that obtained at home being but part of the main object, but tending materially to diminish the mortality.

The copious and instructive Report upon Hospitals for Infectious Diseases, by Dr. Thorne Thorne,[1] covers all the details of the subject; it will only be possible within the present limits to touch upon main points.

Temporary hospitals usually consist of tents, huts, or buildings constructed of canvas, wood, or iron, with or without more or less solid foundations and flooring. The advantages of treating the infectious sick in temporary structures, erected in the open, has been amply demonstrated on a large scale in military warfare in various parts of the world. But the use of temporary structures where permanent provision is necessary is unsatisfactory, and ultimately more expensive; for although there may be a saving in the first cost of erection, the cost of subsequent maintenance is greater than that of permanent buildings.

In the open country tents are readily erected, and during the warmer seasons are a convenient method of rapidly supplying means of isolation in an emergency. They require to be waterproof, well ventilated, and supplied with a solid wooden flooring. The hospital tents designed by Dr. Netten Radcliffe to hold three or four beds, are probably the best of their kind. By multiplying the number of tents accommodation may be provided for more patients, as well as for administrative and for service purposes, so that a complete encampment may be formed.

The well-known ready-made portable hospital huts invented by Captain Döcker of Copenhagen, constructed of

[1] *Tenth Annual Report of the Local Government Board.*

light wooden frames filled in with card-felt, are well adapted for rapidity of erection. They are intended to be as portable as tents and as convenient in form as the more substantial huts, and occupy an intermediate position in this respect between the two kinds of erections. They possess the additional advantage of maintaining greater uniformity of temperature.

Hospital huts are usually constructed of wood or iron, raised upon masonry supports, ventilated below the floor, and by upcast inlets below the eaves, and cross ventilation at the ridge. Each hut should form a pavilion complete in itself, containing nurse's room, bath, water-closet, sink, kitchen, and scullery, and be adequately lighted and warmed. Huts constructed entirely of iron are especially liable to wide variations of temperature unless well lined with felt and wood.

In small communities the adaptation of a cottage or small house for the purposes of an isolation hospital is frequently resorted to with success. The primary object is isolation, and provided the condition and adaptation of the structure are not prejudicial to the patients, and the management is efficient, much may be effected in an economical manner upon a small scale.

Another class of hospitals, of which only a few examples exist, but which are of undoubted value, are those set apart for the purpose of isolating infectious diseases with a prolonged convalescent period, such as the Convalescent Hospital of the Metropolitan Asylums Board at Winchmore Hill, and the Mary Wardell Convalescent Home for scarlet fever. The solution to the difficulties attending the isolation of measles, and of the minor infectious diseases of children, would appear to lie in this direction of providing special convalescent homes. Loeffler and also Roux have pointed out that virulent diphtheria bacilli remain about the mucous surfaces for several weeks after the patient has apparently completely recovered, and the danger of returning these patients to their families and to school too early requires to be averted by convalescent homes, which serve the purpose also of affording change of air and re-establishing health.

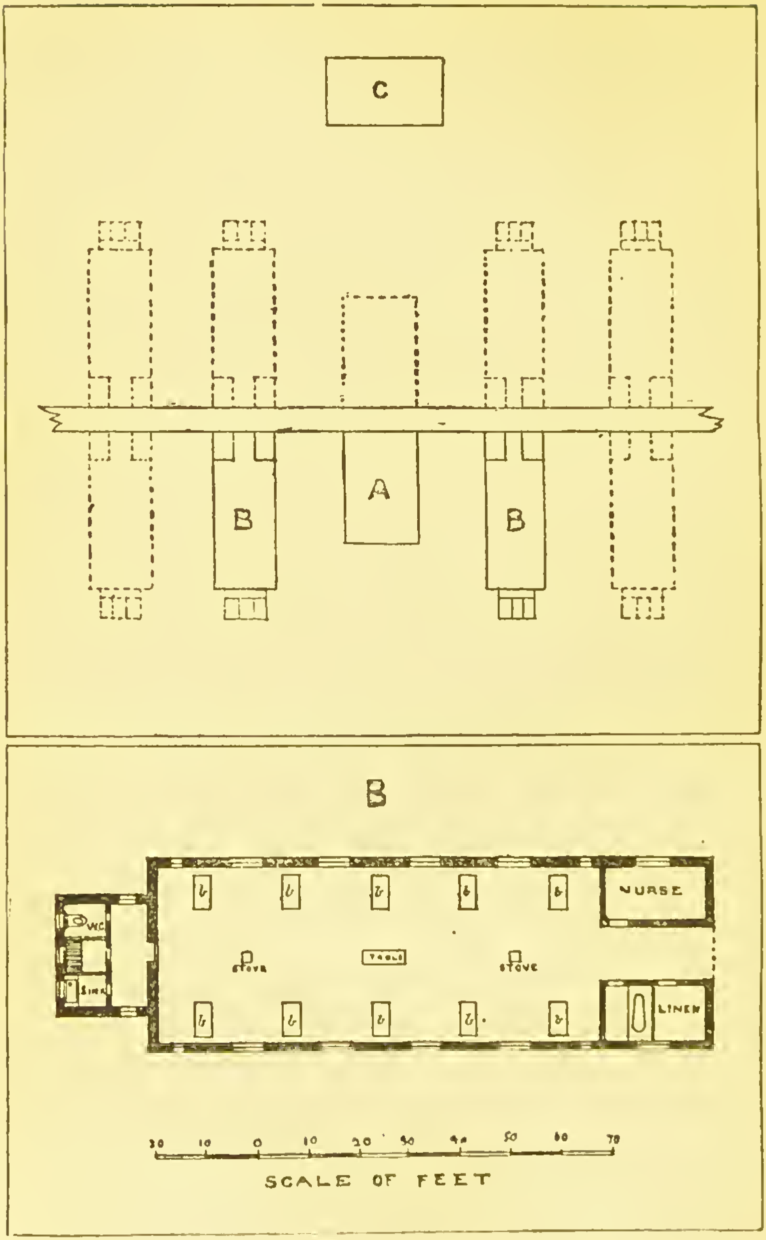
Tenon was the first to enunciate, in 1787-88, the idea of

constructing hospital wards upon the pavilion principle, and this principle was applied for the first time in the construction of the Lariboisière Hospital, Paris, in 1854; since that date numerous modifications and improvements have led to its more or less general adoption. The principle is specially suited to the construction of infectious hospitals, and is now universally adopted for permanent isolation hospitals. Each pavilion or block is separate from the others, or connected only by a covered way. Provision is made for both sexes, and for the necessary nursing, store-room, bath-room, water-closet, and other accommodation. Certain wards are also set apart for the convalescent, and for the probationary observation of doubtful cases.

Probationary wards should never fail to be provided in all infectious hospitals. It is sometimes extremely difficult to diagnose an infectious case correctly at the onset. In the meantime the rest of the family or of the household in crowded dwellings may run great risk. The medical attendant is justified in advising isolation, and with proper dwelling accommodation this may be carried out; he is not the less justified in advising removal to hospital where the accommodation is inadequate. It therefore remains for the hospital authorities to provide such means of isolation as may avoid both the retention of such cases in crowded dwellings, and the infection of the patient, if after removal to hospital it should ultimately transpire that a non-infectious or less dangerous malady develops itself.

A permanent isolation hospital must be so disposed in plan as to provide ward blocks, an administrative block, and a service block or outbuildings. An area of ground is enclosed around the several buildings sufficient both to secure ample isolation and aëration, and also sufficient to be held in reserve, available either for permanent extension, or for the purpose of temporary erections at epidemic periods. It is usually held that the number of beds provided should be in proportion to one for every thousand of population, but this will depend upon local requirements, the number of diseases admitted, and the class of population.

The use of constructive materials that will neither absorb nor harbour the germs of disease, and that will permit of efficient purification when a ward is vacated, is essential.



Plan of Pavilion Hospital, with detail of Rectangular Ward.
A. Administrative block; B. Ward blocks; C. Service block

Provision must be made in separate wards for each of the diseases, and for both sexes, allowing 2000 cubic feet of air space, and 166 square feet of floor space for each patient, and ample means of ventilation.

The administrative block affords accommodation for the resident officers, the staff, the servants, and the necessary offices.

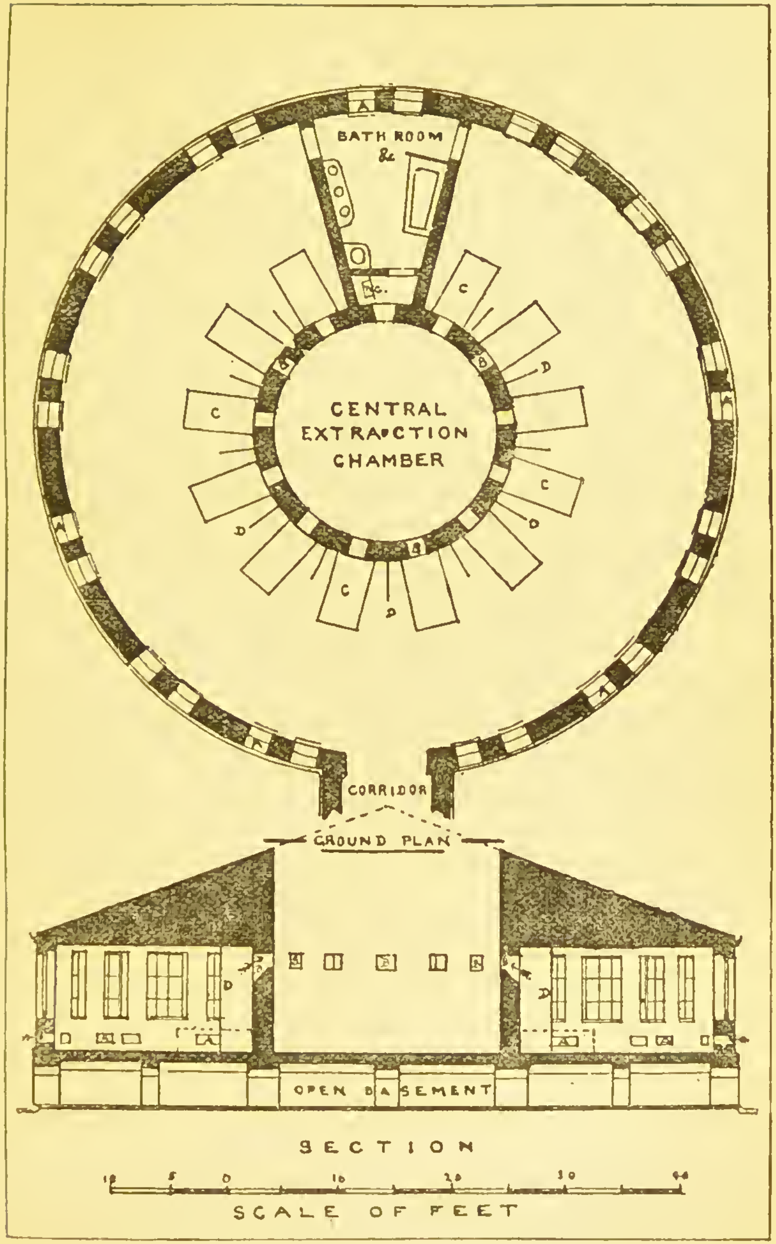
The service block and outbuildings consist of ambulance house and stables, disinfecting chamber, laboratory, post-mortem room, mortuary, laundry, and lodge.

A small-pox hospital requires to be separately administered, and to be constructed on a specially isolated site, on account of the facility with which the disease extends beyond the hospital boundary. At the Metropolitan Asylums Board's Small-pox Hospital at Long Reach, it is imperative that every officer or servant leaving the precincts shall pass through a special process of disinfection in a building set apart for the purpose. This building is so arranged that the person enters an undressing room where the infected clothing worn at the time is entirely removed, and is deposited until return; from this room the person enters a bath-room in which a complete bath is taken, washing the hair not being omitted; the exit from this bath-room is by a door on the opposite side, leading into a dressing-room in which other clothing, free from infection, is stored ready for wearing by the person quitting the hospital on leave. The hospital itself is situated partly on ships moored in the river Thames, near the southern shore, and partly on the adjoining land, which is an area of ground isolated and remote from dwellings. This site was adopted in consequence of the strong evidence of Mr. Power and others, that small-pox tended to diffuse itself, apart from the infection carried by persons entering and leaving, aërially and centrifugally in the neighbourhood surrounding a hospital; the only other method available to prevent this, being the construction of a hospital upon a plan that would admit of the treatment of the outgoing air from the wards in such a manner as to deprive it of infectious particles.

The principle of passing the air of a hospital, occupied by infectious persons, through fire was first proposed by Dr. Richardson, in a paper read before the Sanitary Institute

in April 1881, recorded in vol. iii. of the *Transactions*, and a small iron model was exhibited to illustrate the process. In 1882 Dr. Burdon Sanderson worked out the details of a plan for the erection of a circular hospital for the reception of small-pox patients, so constructed that the vitiated air should be extracted and passed through fire, and this was laid before the Commission on Small-pox and Fever Hospitals then sitting. The system is illustrated in the accompanying plan, reproduced by permission from the elaborately illustrated work on Hospital Construction and Management by Dr. F. J. Mouat and Mr. H. Saxon Snell, and the substance of the evidence of Dr. Burdon Sanderson is contained in the following extract from the report of the Commission:—

"I assume, in reference to this subject, that it is necessary that we should possess in London, hospitals for the reception of the most acute cases of small-pox, and consequently that for that purpose it would be desirable that hospitals should be constructed on a principle not hitherto recognised in their construction—*i.e.*, with regard to the welfare of the surrounding neighbourhood, and not only with regard to the welfare of the inmates of the hospital. With this view, it is in the first place necessary that the hospital should be ventilated artificially, in order that the air used by a patient may, after it has passed through the hospital, be subjected to high temperature or some other means of destroying whatever dangerous properties it may possess before it is discharged. As the outlets of air are the sources of danger, and not the inlets, it is preferable that the air should be drawn out of the hospital, and not driven into it, and consequently we should choose a mode of ventilation accordingly, and that being adopted, the beds for the patients should be placed as near the outlets of air as possible; and further, the outlets themselves should be as near together as possible. The communication between the outlets and the source of motion, whatever its nature might be, should be as direct and ample as possible. Considering all these purposes, it is desirable that each ward should be in the form of a ring, with the chamber from which the air is directly extracted in the centre of the ring, the annular being the simplest form that can be given to it—that is to say, the one that makes it possible to make the opening for extraction of air communicate more directly than any other with the space in which each bed is contained. Then for a ward of twelve beds, having a capacity of about 1,200 cubic feet per bed, the removal of the air should be about 120,000 cubic feet per hour, and, consequently, the removal of air per patient 10,000 cubic feet per hour. The exact form of the ward which I should propose is shown by this model, which I will proceed to explain. Let me say that this fan which is placed here is not analogous in form or size to the motor which one would actually use for extracting air from a ward; it is analogous in structure, but in relation to the size of the ward it is incomparably larger. The annular



CIRCULAR HOSPITAL WARD.

form of the ward is shown when I take away this movable part which represents the external wall. These openings round the lower edge are the openings by which the air would enter into the annular space. This is the internal wall of the annular space, and in this internal wall there are twelve openings corresponding to the twelve beds, which are of the same relative size as these. The beds would be arranged as near as possible to, and immediately below, each extracting opening, and would be placed against the internal wall, and each bed would be placed between two of the septa or screens, which pass to a certain distance out from the internal wall into the annular space, so that the head of each bed would be included in the space between each two neighbouring septa. The space within the ring communicates with the annular space which answers the purpose of the ward, by the extracting openings, and also with an extractor, preferably a fan. An extracting shaft might, of course, be substituted for a fan, but I think a fan preferable, on the ground that its action is more independent of temperature and wind, and, therefore, more constant, and that it is more economical. The fan would collect the air from the ward, and at once discharge it into a chamber where it could be subjected to a high temperature, so as to destroy all organic matter it might contain. That I think constitutes the whole description of the ward.

"This ward is intended to communicate with the outside only by the corridors, and to have no openings, excepting the openings for ventilation. The windows would not open. There would be two modes of entrance, one for the nurses, which would be, in fact, a dressing closet, that is to say, a closet for changing dress, and another opening from the corridor, principally for the medical attendant, and also a window for the introduction of diets and other things required for the use of the patients.

"A fan of some kind is the *modus operandi?* Yes, a fan of some kind. As I said just now, what is required is that there should be removed 120,000 cubic feet per hour from the whole ward; and supposing a ward of twelve beds, that is 10,000 cubic feet for each patient, and that would involve, supposing the air spaces to be as I have represented them, that is upon the scale given upon the model—namely, each of these round outlets having an area of actually about two square feet—the result would be that the air would pass over the patient's bed at the rate of about one mile per hour. The construction is such that the rate of exhaustion from each opening would be at the rate—that is to say, the motion through the outlet would be at the rate—of about one mile per hour, and consequently there would be no unpleasant draught, although the ventilation would be very abundant. I think all I have to add is in reference to the administration of such a ward. A ward of this kind would require probably two nurses at least to administer it, and take charge of as many as twelve severe cases. I assume that they would remain on duty not more than eight hours at a time, and consequently they would not need to be provided with any comforts which are usually placed at the disposal of hospital nurses when they have to remain the whole day. As regards the medical administration it is obvious that the ward must be open to the visits of the resident medical officer, and that the whole of the management of the ventilation should be under his superin-

tendence, otherwise it would not be possible to carry out the thing satisfactorily. The plan adopted involves the necessity of controlling the openings for ventilation; if, for example, all the openings were opened upon the wrong side, you might disturb the action of the ventilation in such a way as to render it futile. I assume that the ventilation would be placed under the direction of an intelligent man, who would know on what principle to regulate the openings. Then as regards warming, the method of warming would be this:—Hot-water pipes will be carried round the front of the external openings, that is, in the neighbourhood of the inlet openings for air, and in that way the ward would be sufficiently warmed. I have already said that the system should be enforced of nurses completely changing their dress after entering the ward and leaving it, and that the nurse should have no need to do anything except attend on the patient during her eight hours' service. It is quite clear that in order to carry out the whole purpose which we have in view there should be attached to each hospital a properly constructed disinfection chamber; take, for example, the one now used in the Strand district, which is well arranged and constructed for the purpose of completely disinfecting the clothes of patients by heat. That of course must be attached to the hospital. I have ascertained by consulting with the architect that no difficulty exists as regards the form which I propose for my ward—namely, the circular or annular form of ward. There would be no constructive difficulty in carrying out a hospital upon such a plan."

The following objections to Dr. Burdon Sanderson's plan have been made by Dr. John S. Billings, surgeon, U.S.A.:—

"It is evident that while it is theoretically possible to thus disinfect the air passing through a small-pox ward, it would be at a relatively great expense. The circular ward is used in the new City Hospital at Antwerp, and the same principle is employed in the Octagon Ward of the John Hopkins Hospital at Baltimore; but in both these beds are arranged against the outer wall, having the heads towards the windows, which is a much more convenient way of arranging them than the plan proposed by Dr. Sanderson, both because it allows more space about each bed, and because it does not put the patients facing the light, which would be extremely unpleasant in the acute stage of small-pox.

"A second objection is that the central shaft is unnecessarily large, as are also the inlets into it. It is not desirable to reduce the velocity of the air at the outlets or in the foul air ducts below 4 or 5 feet per second, because at very low velocities a very slight thing will disturb the currents. The velocity at the outlet has comparatively little to do with the production of draughts. There seems to be no necessity whatever for the use of an aspirating fan in the plan proposed. If the air is to be heated to a temperature of 250° F. and upwards, which is necessary to secure its disinfection, this heat will in itself furnish all the aspirating power required. The use of gas to produce the heat required for such large quantities of air would be unnecessarily expensive; a coal furnace would do the same work at half the cost.

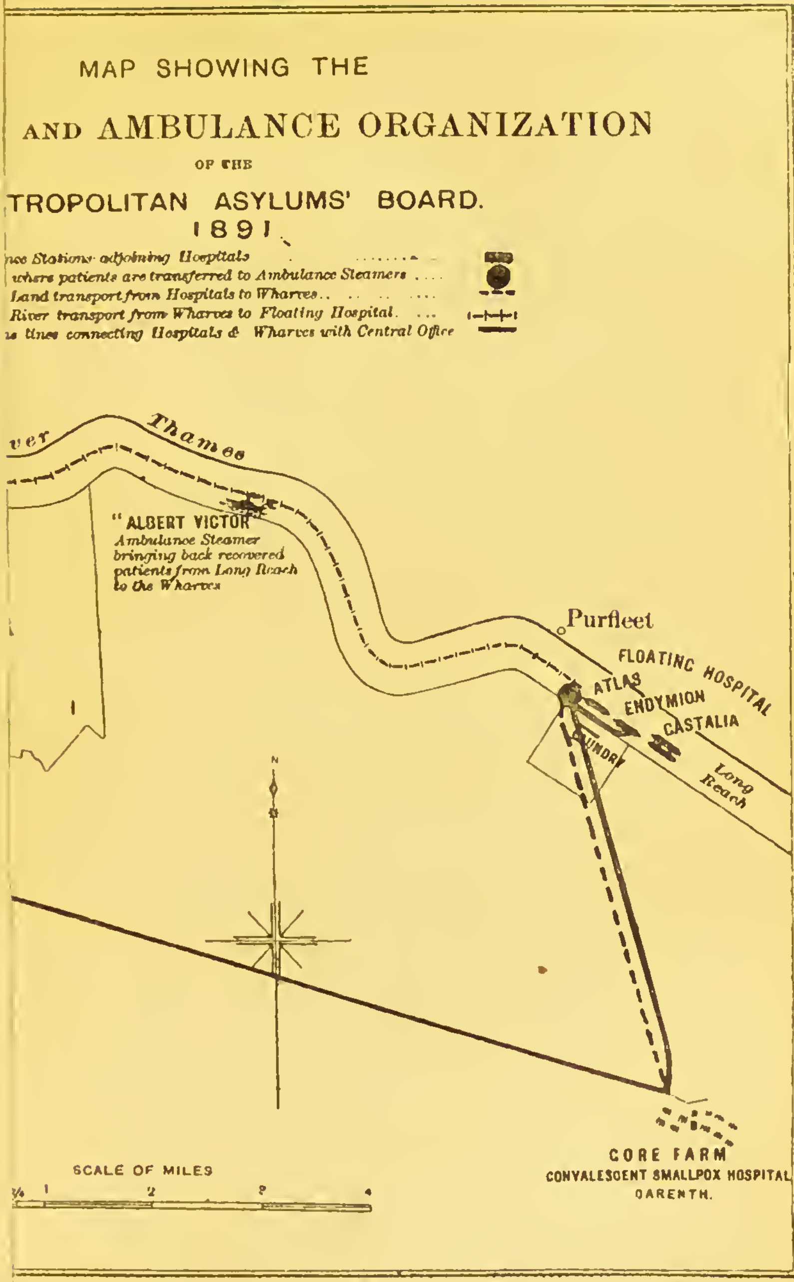
"In the plan proposed, in cold weather, a large amount of the

incoming fresh air, and the heat employed in warming it, would be wasted, since it would rise rapidly from the point of entrance, taking almost a direct line to the point of exit, and passing above the beds, the occupants of which thus get no benefit from the main stream of fresh air, but must rely on what comes to them from a sort of eddy, and from diffusion.

"It would have been better to introduce the greater part of the air through a grating beneath and between the beds, in which case patients could be kept bathed in a steadily ascending stream of air, moving at the rate of say four miles per hour. And this would be effected with less than half the amount of air and expenditure of fuel required in the proposed plan. It should be remembered that in a hospital of this kind, where special arrangements are to be made to secure a steady, uninterrupted stream of air through the ward, the allowance of floor space and cubic air space per patient become of secondary importance, so far as ventilation is concerned, and may be fixed mainly by considerations of convenience of administration. This ward might be made 10 feet less in diameter, and the central shaft reduced to 4 feet in diameter, with good effect. These suggestions are made, not for the purpose of fault-finding, but because everything which comes from such a distinguished authority should be made as perfect as possible."

The conveyance of the infectious sick is rendered so easy and simple, by means of the excellent means of transport devised of recent years, that the distance of a hospital, provided it be not excessive, is not of so great concern as some few years ago it was estimated to be. The disadvantage of attempting to install temporary isolation almost at the doors of houses attacked by an infectious outbreak must be obvious, and it becomes unnecessary now that ample experience has proved the fallacy of the idea that transport is fatal to endemic infectious diseases. Far from being fatal, the results would tend to show rather that it is beneficial and more nearly approximates to the condition of treatment under canvas in the open, provided the patient be well protected, that the movement be reduced to a minimum, and that a skilled nurse be in attendance.

The excellently organised ambulance service of the Metropolitan Asylums Board is the best type existing on a large scale. Certain hospitals have ambulance stations attached to them, equipped with all that is necessary for service at short notice. At any hour of day or night, upon receipt of a telegraphic or telephonic message, a fully equipped ambulance is available to remove a patient to any of the Board's hospitals or elsewhere, a charge being


MAP SHOWING THE
AND AMBULANCE ORGANIZATION
OF THE
TROPOLITAN ASYLUMS' BOARD.
1891.
nce Stations adjoining Hospitals
where patients are transferred to Ambulance Steamers
Land transport from Hospitals to Wharves
River transport from Wharves to Floating Hospital
lines connecting Hospitals & Wharves with Central Office
ver Thames
"ALBERT VICTOR"
Ambulance Steamer bringing back recovered patients from Long Reach to the Wharves
Purfleet
FLOATING HOSPITAL
ATLAS
ENDYMION
CASTALIA
Long Reach
SCALE OF MILES
CORE FARM
CONVALESCENT SMALLPOX HOSPITAL
DARENTH.

made only when the patient is conveyed elsewhere than to a hospital of the Board. Small-pox cases are transferred at the wharves from the land ambulances, in the stretchers as they lie, to the river ambulances, which are small steamers that ply between the wharves and the ships at Long Reach. The river passage is an easy and comfortable means of transit in which distance is of small moment.

The enlistment of the telephone into the service for isolation of infectious disease is a valuable application of this modern appliance. It enables hospitals to be placed at a distance, and yet to be in instant communication with the central office of the Board. To a large extent the risk of visits to the infectious sick may be avoided with such a ready means of inquiry at hand. It enables the Metropolitan sanitary authorities to be placed in instant communication through the central telephone office with the central office of the Board, and so with the ambulance stations. And it may be said that the rapidity and efficiency of the London ambulance service is largely due to the value of the telephone and telegraph as a means of intercommunication, freed from the risks of contact with infection.

The influence of careful isolation in reducing the morbidity and the mortality from small-pox in the Metropolis has produced marked results in recent years. Another large town affording the strongest evidence of the preponderating value of isolation is Leicester, where a large unvaccinated population offers a susceptible soil for the propagation of small-pox. Immediate notification, and rapid isolation and disinfection, have for years past preserved Leicester from an epidemic. But it must also be remembered that all officials and servants brought into contact with the infection have either been vaccinated or have suffered from a previous attack of the disease, and have been thus protected from the disablement that would otherwise have led to the breakdown of the system. Furthermore, all persons who have come into contact with an infected person have been either immediately vaccinated, or have been detained under observation until expiration of the incubation period of the disease. Some degree of protection must also be attributed to the fact that surrounding

communities have also been protected by the practice of a certain amount of isolation and disinfection and by vaccination, so that the points from which infection might be imported into the town have been correspondingly reduced.

The experiences of Sheffield during the epidemic of 1887-88, detailed in the voluminous report of Dr. Barry to the Local Government Board, are an evidence of the disastrous results following upon imperfect isolation. Dr. Buchanan, in his introduction to and summary of the report, points out that during the invasion period of Sheffield a good many cases of small-pox occurred that did not come to the knowledge of the sanitary authority; and, as for its disinfection and isolation arrangements, the former were, before the outbreak, of a very rudimentary kind, and the latter were imperfect through faults of administration and of situation, the hospital adjoining the most densely populated district and becoming the centre of the epidemic extension.

Although the beneficial effects of isolation are most readily observable in small-pox, in other infectious diseases the mortality affords a gauge of its efficacy. With the steady increase of isolation in hospitals the mortality and morbidity rates steadily fall in an approximate ratio. Every restriction upon the use of such hospitals is therefore to be avoided; charges for conveyance, maintenance, treatment, and other purposes, render them useless to the poor, who require them most, and reduce them to isolation hospitals only in name. Infectious disease is an uninvited misfortune to the individual and a danger to the community, and its seclusion should be provided for at public expense.

To this must be added disinfection, as the supplement to isolation and the completion of the process for eliminating infectious disease from the dwelling and personal apparel.

An additional measure of isolation is indicated when a fatal result ensues upon a rapid attack of infectious disease within the restricted limits of the indigent dwelling. The law empowers the sanitary authority to remove the body at public expense to a proper place for its reception, and a mortuary for the infectious dead requires to be provided. This is a provision demanded on the ground of humanity as well as that of prophylaxis.

As to the disposal of the infectious dead, public opinion in this country must reconcile itself more to the crematorium before it will be possible to obtain the adoption of cremation as a measure to be applied on a practical scale. As a measure for the destruction of infection, burial in fire is immeasurably superior to burial in earth.

CHAPTER IV.

DISINFECTION AND ITS EFFECTS.

Disinfection, strictly speaking, implies dealing with infection, but in its popular and wider sense it embraces purification in all its applications. The burning sacrifices of volatile substances, the libations of liquids, and the sprinklings of powdery compounds on a large scale, are now recognised as feeble or futile substitutes for the physical and chemical means of destroying infection. The efficacy of disinfection may broadly be said to be in inverse proportion to the scale upon which it is carried out.

In the process of cleansing and purification in their widest sense, stable and unstable, organic and inorganic substances are dealt with either by physical or chemical means. By physical means, when applied to movable matters and without regard to their preservation, they are removed by road or water, and disposed of upon the surface, or by burial, or by burning, according to the proximity of dwellings and other conditions. When applied to objects not removable, washing, scraping, dusting, and other processes are resorted to, the resultant refuse being discharged or destroyed. These are merely parts of the multifarious methods of cleansing, which should be adopted always in addition, or in preference, to the more temporary measures resorted to by the use of chemicals for the purpose of treating organic decomposing matters. It is this process of chemical treatment of decomposable refuse that popularly and fallaciously passes under the name of disinfection. This is fostered by the popular habit of styling many and varied substances *disinfectants*.

Decomposition and putrefaction are now well known to

be the result of micro-organic life in the beneficent work of resolving organic substances into their innocuous elements. During this transmutation malodorous gases are given off, and *deodorants*, whether by overpowering or by absorbing, or by breaking up the gases, produce little or no effect upon the decomposing substances. Odours are the tell-tales of filth, and simply masking them is a fallacious remedy. To prevent the odoriferous stage being reached preservation against decomposition is practised by the use of *antiseptics*, but their application is limited to substances and places where removal or destruction are undesirable, temporarily or permanently, and they require careful and discriminate employment to be of value in preventing the effects of access of micro-organisms.

In passing may be mentioned the preservation of food by physical means, as cold, exclusion or filtration of air, and by chemical means, as smoking, salting, and the use of various chemical substances. Their interest here only lies in the fact that *preservatives* are allied closely to antiseptics in their effects upon organic substances.

The most effectual kind of antiseptics are those which not only inhibit microscopic life, but are directly fatal to it as *germicides*. This implies the actual destruction of the germs, and the measure of this power requires more exact verification than the mere prevention of decomposition, which antiseptics may be held to infer, although many germicides in a diluted or weakened state become or act as antiseptics.

Disinfection in a more restricted and accurate sense, implies the destruction of the infection produced by the specific micro-organisms of disease, as distinguished from pollution by micro-organic life generally. Although it must be admitted that our knowledge as yet scarcely enables us to draw any sharp line between pathogenic and non-pathogenic organisms, and especially in reference to the causation of septic diseases, yet in the recognised infectious diseases, whether the specific organisms have been found or not, disinfection is applied to the destruction of the specific infection. The only means of judging whether this destruction is effectually accomplished is by actual experiment upon cultivations of known microbes, a method that has

largely displaced the earlier rough process of measurement by the retardation of decomposition.

Thus restricted to the destruction of specific infection, the process of disinfection admits of the application of various measures by mechanical means, and by physical and chemical agencies. The mechanical means include the common processes of cleansing; and although it is specially important to observe cleanliness in the presence of infection, yet these means cannot alone be trusted for effectual disinfection. Exposure to light and air exerts a destructive influence upon the contagia, the length of exposure required varying according to the resistance of each particular virus. Whereas the infection of typhus is readily dispersed and rendered inert by ample aëration, it is probable that, in those diseases in which the virus may be cast off by desquamation, the protection of the scabs or scales in which it is enveloped may explain the greater resistance to destruction and the greater distance to which it is transportable. Those portions of the contagia that are exhaled or pass directly into the air, are more open to the effects of light, air, humidity, and temperature, and lose their virulence more quickly, than those protected from these influences by the media in which they are embedded, as the epidermis in desquamative diseases like small-pox; the buccal secretions and sputa in diseases affecting the throat or respiratory tract, as diphtheria and pulmonary phthisis; the alvine excreta in diseases affecting the digestive tract, as typhoid, cholera, and dysentery; the pus and discharges in diseases accompanied by external lesions, as syphilis, glanders, and anthrax; including also diseases in which the contagium is eliminated by more than one of these media, as scarlatina and measles, from both the skin and the mouth. It is probably also due to the protective influence of the *débris* of tissues within which the contagia are cast off, and the want of penetrative power, that gaseous disinfectants may prove inefficacious, and except as purifiers of contained air they cannot be solely relied upon to disinfect interiors and their contents.

The more rapid physical agent used for disinfection is heat. Omitting destruction by fire, which is the most summary and complete manner of destroying infected

objects of little value, heat is applied in two forms, for the purpose of destroying contagium without perceptibly injuring the object infected, either as moist or as dry heat. The earliest experiments with moist heat were those of Tyndall, who sterilised fluids containing putrefactive microbes by two or three repeated boilings at intervals, having failed to produce absolute sterility by a single prolonged boiling. From this it cannot be concluded that a single boiling will not destroy or enfeeble the microbes of communicable diseases so as to render them innocuous, since there is positive proof to the contrary in the greater or less protection afforded against certain diseases by boiling contaminated milk, and laboratory experiments have shown that inoculations of septicæmic blood (Dreyer) and of cultivations of anthrax bacilli containing spores (Klein) that have been boiled from one to five minutes, have proved incapable of injury; so that in practice the simplest method of disinfecting such objects as permit of it (washable articles) is by boiling for fifteen to twenty minutes, to insure actual boiling and not mere simmering. Objects injured by boiling, or too bulky to be thus treated, may be disinfected by dry heat, as applied by baking, or by moist heat, as applied by steam. Steam injures leathers, furs, and objects in which glue is used, as books, etc., and dry heat or hot air is the only method available for disinfecting articles that will not bear moist heat; even then it must be used with great care. It is but a few years since that hot air was the only method applied to cloth and bulky materials. The experiments of Koch and others, in 1881, with hot air and steam upon microbes and spores, lead to the valuable conclusion that hot air is much inferior to steam as a germicidal agent.

These experiments were conducted with various micro-organisms, the most important of which was the anthrax bacillus, both on account of the fact that it is associated with a disease fatal to animals and man, and that it is most resistant to destruction, especially in its spore-bearing condition. Any tests therefore successfully applied to the destruction of this organism would imply a successful result when applied to the less resisting contagia of other infectious diseases; and although these might be destroyed

by less heat, yet safety is to be found in adopting the higher degree.

The conclusions that Koch came to in reference to dry heat were, that it required a temperature of 212° F. maintained one hour and a half to destroy spore-less bacteria, a temperature of over 230° F. maintained the same length of time to destroy the spores of fungi, and a temperature of 284° F. maintained for three hours to destroy the spores of bacilli; that dry heat penetrates so slowly, that articles of moderate size, as bundles of clothes and pillows, after three or four hours' exposure to a temperature of 284° F., were not disinfected, and that exposure during this time to such a temperature damaged most fabrics. On the other hand, the results obtained with steam showed that an exposure of five minutes to steam at 212° F. sufficed to kill anthrax spores, and that the penetration into bulky articles was much more rapid.

These results have been carefully confirmed from other sources by Dr. Parsons, in his very complete account of disinfection by heat contained in the Report of the Medical Officer to the Local Government Board, 1884. The complete sets of experiments by Dr. Klein, quoted in the report, confirm the strikingly superior results of steam as a germicide.

The disadvantages of dry heat or hot air as a disinfectant are many, the unequal distribution of heat in the disinfecting chamber, the difficulty of maintaining the temperature at a uniform degree, the uncertainty of the index of the temperature of the interior, the length of time necessary to heat the interior to the required degree, the want of power to penetrate stuff materials, and the greater length of time required to exert its germicidal action. By steam these

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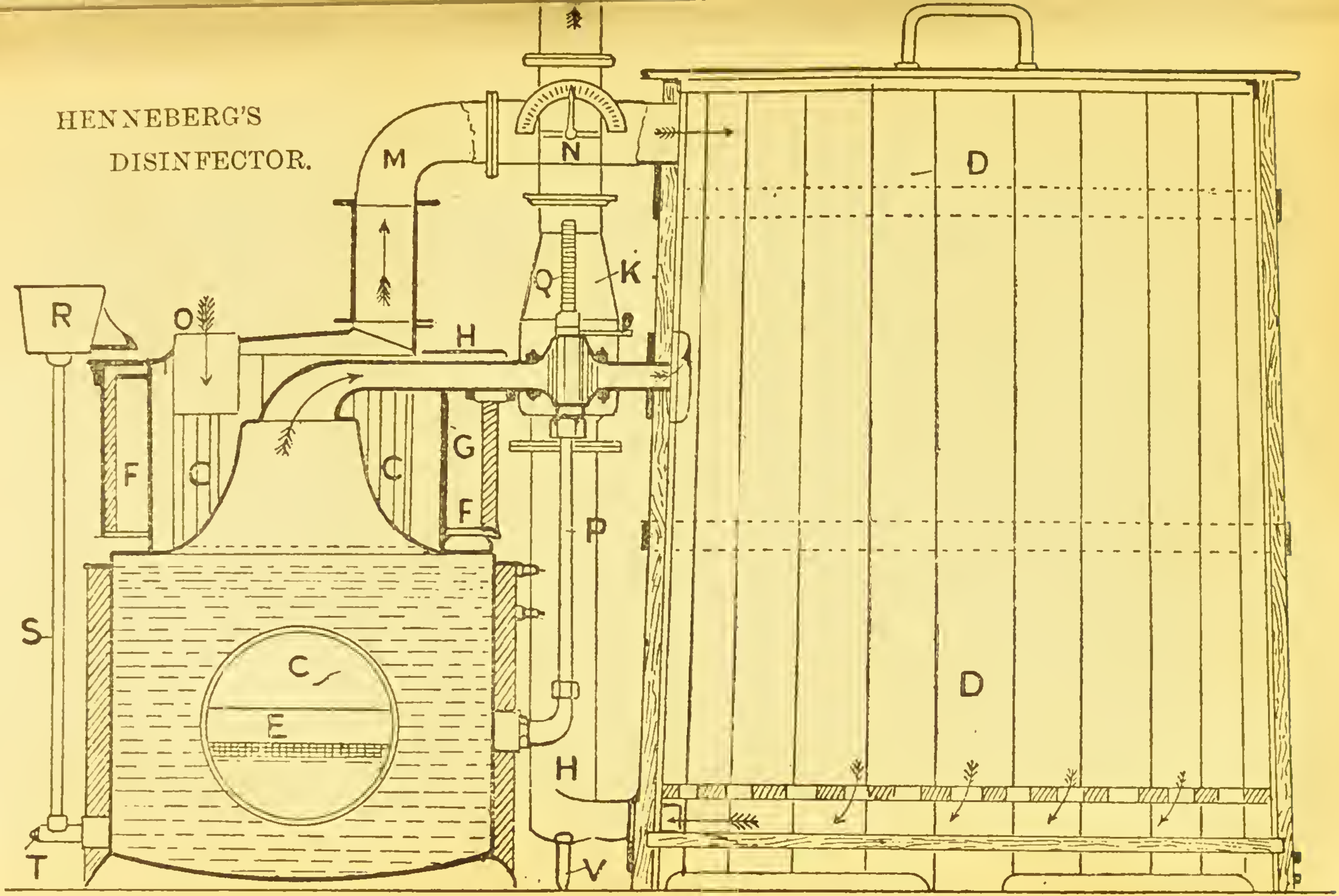
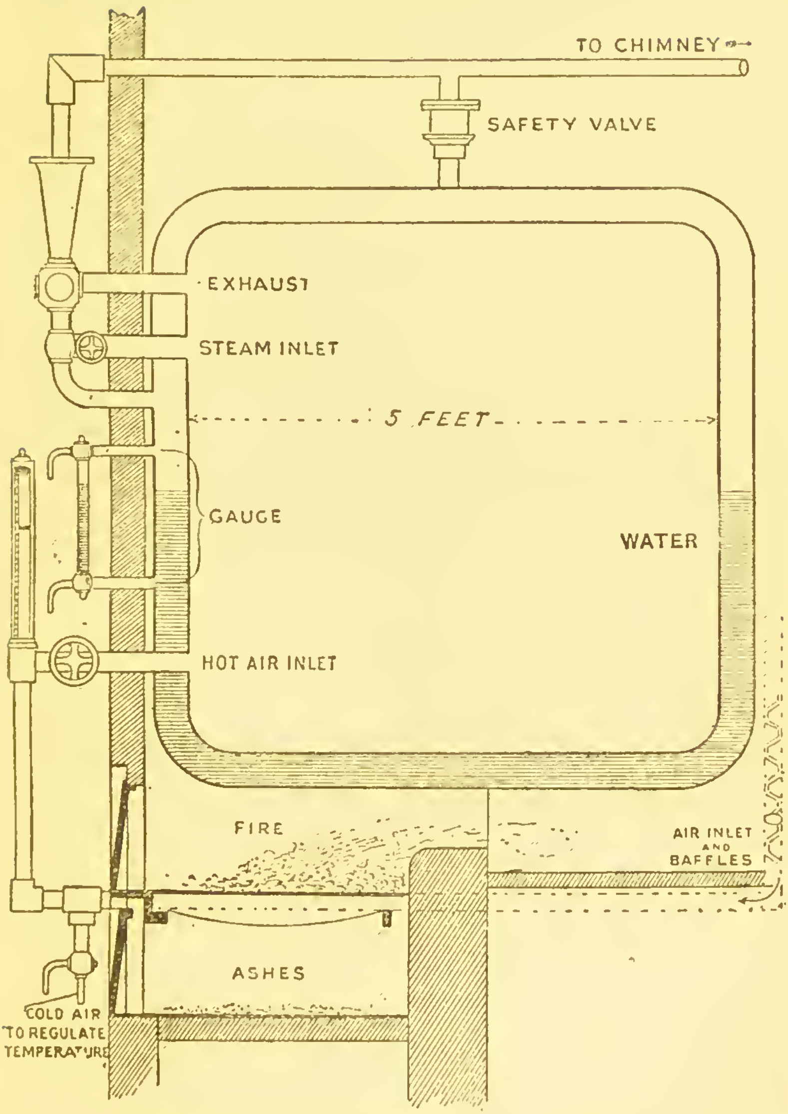
NOTE TO ILLUSTRATION.—A, boiler; B, furnace; C, air heating box; D, disinfecting chamber; E, grate; F, fire-flues heating air-box; G, smoke-tube leading to chimney flue; H, steam-pipe; I, valve turning steam into chamber or into open; K, steam and hot-air outlet tube; L, outlet openings in chamber floor; M, tube delivering hot air from air-box to disinfecting chamber; N, throstle-valve on hot-air tube; O, cold-air inlet; P, water-gauge; Q, thermometer at outlet; R, water-funnel for filling boiler; S, water inlet tube; T, water inlet valve; V, steam cock for condensed water; W, safety-valve set to a pressure of $\frac{1}{20}$th of an atmosphere.

HENNEBERG'S DISINFECTOR.



disadvantages are overcome, the germicidal effect is more rapid, there is no liability to scorching, the temperature of the interior is quickly raised to the required degree, and the penetration of bulky articles is more rapid and complete. The penetration is materially increased by using the steam under pressure; this also more uniformly distributes the temperature and enables the pressure to serve as a more accurate indicator of the degree of heat, by means of the pressure gauge; furthermore, by regulating the pressure, complete control may be exercised over the temperature. On these counts high-pressure steam is more valuable than steam at atmospheric pressure, or than current steam. It possesses the further advantage of enabling the pressure to be varied, so that by intermittence more rapid and complete penetration of very bulky objects may be obtained. Steam is specially applicable for the disinfection of bedding, cloth clothing, and stuff furniture; to avoid the shrinkage of such objects, from the wetting effect of the steam by condensation, the outer wall of the chamber is duplicated, so that a jacket in which high-pressure steam circulates, surrounds and slightly superheats the steam contained in the interior, thus reducing the condensation. This surrounding jacket is also useful for the purpose of converting the chamber into a dry heat chamber when excluding steam from the interior, the temperature being controlled by a second pressure gauge showing the pressure of steam in the jacket. By this means objects that would be ruined by steam may be carefully subjected to dry heat, and in fact such a hot-air chamber is a better form than can be obtained by most other methods of construction.

The various forms of steam disinfecting chambers in use differ in construction according to whether a current of steam or high-pressure steam is employed, whether the steam is admitted from below or from above, and whether the boiler is separate or is contained in the outer jacket of the chamber. The most typical form of apparatus in which current steam is employed, produced in a separate boiler, and admitted from above downwards, is perhaps that of Henneberg of Berlin. Hot air is admitted from above in order to drive out the cooler air from the chamber, and from the interstices of the contained articles. Steam is



SECTION THROUGH DISINFECTING CHAMBER

subsequently admitted, being directed upwards by the guard over the steam inlet. Both the hot air and steam find their outlet below. The boiler is separate from the chamber, which is not double-jacketed, but is framed in non-conducting material.

Of chambers constructed with the boiler in combination, and in which current steam is employed, Schäfer of Berlin, Thursfield, and Brückner of Vienna, have made several forms; in some the steam enters from below, and in others from above, but the best example of this combination is the chamber of Professor van Overbeek de Meyer of Utrecht. The use of current steam has demonstrated the advantage of hot air or steam admitted from above downwards, in displacing the cooler contained air in bulky articles, reducing the condensation and wetting, and increasing the penetration of the steam. Similarly, the combination of boiler and chamber has shown that greater economy of heat, more complete absence of condensation, and greater economy of space result. This combination is effected in a double-jacketed chamber, by filling the lower half of the space between the two jackets with water, which thus acts as a boiler with the furnace below.

A chamber in which high-pressure steam is used may also be constructed with a separate boiler, or with the boiler in combination with the chamber. Of the former type, those of Schimmel of Berlin, of Geneste and Herscher of Paris, and of Lyons of London are best known; the two latter are almost similar. This type consists of a cylindrical chamber with double jacket, between the inner and outer casing of which the steam circulates in the first place. As soon as the temperature of the outer jacket is raised sufficiently, the steam is admitted into the inner chamber to the pressure required, and as the pressure in the outer jacket may be raised above that in the chamber, the steam in the latter may be superheated to the extent of the difference of pressure.

The chamber of Goddard and Massey, of Nottingham, is constructed with a boiler in combination, like Overbeek de Meyer's; the diagrammatic section illustrates the principle. It is essentially rectangular in shape, for convenience in charging, 5 feet square in section, and 6 feet 6 inches in length, allowing full-size mattresses to be deposited full

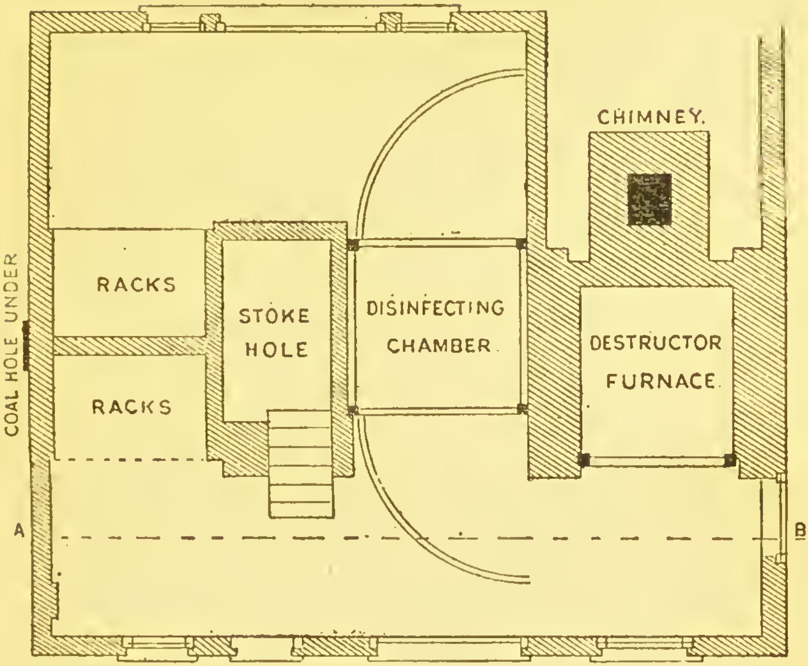
length, and capacious enough to undertake the disinfection of articles for a large district. It is entirely surrounded by a double jacket, and the doors are also double-jacketed, so that surface condensation is completely prevented. The space (about 4 inches) between the two jackets is filled, the lower half by water, and in the upper, as well as in the door, the steam circulates. The water is heated by a furnace beneath, and from the time of lighting it takes under an hour to get up steam. On the top a safety-valve, weighted to 20 lbs. pressure, is situated. Steam is admitted into the chamber from the jacket through a screw-down valve, and it is withdrawn through a similar valve by a steam exhaust pipe discharging into the chimney. Two dial pressure-gauges over the door mark the pressure and temperature in the jacket and chamber, respectively. A supply of hot air is laid on through a channel furnished with baffles, running from the back along the side of the furnace, and discharging through a screw-down valve into the chamber. This pipe is furnished with a thermometer to mark the temperature of the incoming air, which is regulated by a cold-air supply tap attached. The hot-air and the steam inlet pipes are carried up to the top of the chamber, and the exhaust outlet pipe to the bottom (this is not shown in the section). The apparatus is worked in the following manner:—The steam being raised in the jacket to 20 lbs. pressure, the chamber is charged with the articles to be disinfected, and the doors are clamped. The exhaust and hot-air valves are opened, the cooler air is withdrawn from the bottom of the chamber and displaced from above by a current of hot air. This thoroughly dries the contained articles, displaces the cooler air from their interstices, and prevents condensation of steam within them. The hot-air valve is then closed and the steam inlet valve opened. This discharges steam at the top of the chamber and produces a downward current towards the exhaust, so that the effect of current steam is obtained, by which means the hot air is more or less completely driven out. This riddance of air permits of the full and rapid effects of the steam alone, otherwise the disinfection would be retarded by a mixture of air and steam. The exhaust valve is then closed and the steam pressure allowed to rise to

the required degree, the maximum being 20 lbs., equal to 260° F.; the same pressure is now marked by both the gauges.

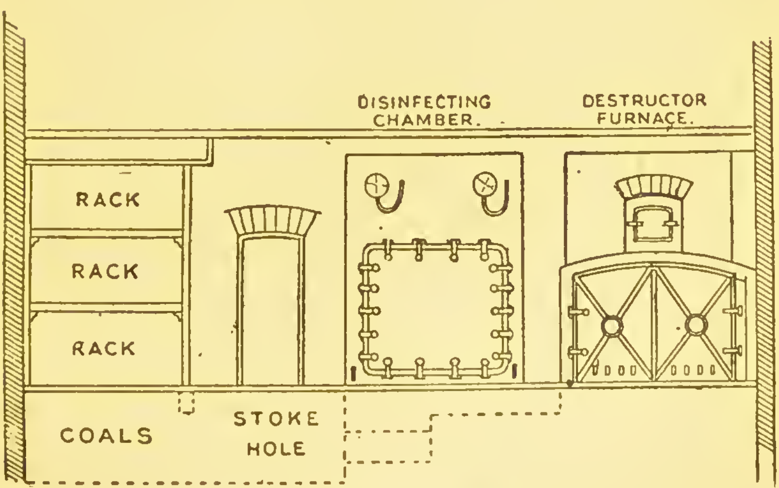
It has been found that for bulky articles the penetration of the steam is quickened by intermittence at this point. Drs. Parsons, Whitelegge, and Ashby have proved this fact, and the writer has also frequently verified it by experiment. It is therefore desirable now to close the steam-pipe and open the exhaust; the pressure runs off in about a minute, then the exhaust is closed and the steam valve again opened. As soon as the pressure rises again the bulkiest article will be infallibly penetrated to its centre. In actual working the process is simpler than would appear in description, and essentially consists in submitting infected articles to a current of hot air, then to a current of steam, and then to high-pressure steam intermitted, and may be completed in from thirty to forty minutes, although penetration may be completed within half this time by omitting the hot air and curtailing the current steam, and for a light charge of small objects half the pressure may suffice; experience in St. Pancras has shown that with heavy charges and bulky goods the complete process and full pressure are necessary. It is convenient to turn on the hot air and drive the steam out of the chamber whilst unclamping the doors; a cloud of steam is thus avoided upon opening, condensation is prevented upon contact with the air, and drying of the articles is facilitated, and rapidly completed during their withdrawal from the chamber.

It is very essential that a disinfecting chamber should open at both ends, so that disinfected objects may be withdrawn without coming again into contact with infected. And in installing the apparatus the two ends of the chamber should open into separate and distinct apartments without direct communication between them, the one side being reserved for infected, and the other for disinfected articles. On the infected side a destructor furnace is a convenient adjunct, for the purpose of destroying useless infected objects, or the refuse destructor of the local authority may be used for this purpose.

Two vans, differently numbered or coloured, are necessary for the collection of infected and the return of disinfected



GROUND PLAN OF DISINFECTING STATION



SECTION A.B.

articles, and in a large urban district horses are necessary to keep pace with the rapidity of disinfection. For these purposes stabling and coach-house are required in proximity to the chamber.

Of the vast number of chemical agents vaunted as disinfectants, very few possess any true germicidal power; a certain number are more or less antiseptic, a large number are merely deodorant, and many are more or less inert. The efficacy of a germicide depends upon the quantity in which it is used, and the length of the time during which it is allowed to act. A true disinfectant may be used in such small quantity, or may be diluted so largely by the medium to be disinfected, that its action may be reduced to infinitesimal proportions, and in actual practice this is what usually occurs.

Koch's experiments upon anthrax spores with a large number of chemical agents in solution showed that they were killed within one day's exposure only by the following:—chlorine, bromine (2 per cent.), iodine, mercuric chloride (1 per cent.), potassic permanganate (5 per cent.), osmic acid (1 per cent.). Oil of turpentine (pure) required five days' exposure, hydrochloric acid (2 per cent.) ten days, ferric chloride (5 per cent.) six days, chloride of lime (5 per cent.) five days, and formic acid four days. As disinfection under ordinary conditions must be completed rather in minutes than in hours, the latter class are out of the question. Of the former, osmic acid is not fitted for practical use, and the quantity of permanganate of potash required would be excessive. There remain therefore mercuric chloride and the halogens.

Mercuric chloride has by common consent been shown to be the most powerful disinfectant in solution at present known. Koch found that one part per million impeded the growth of anthrax bacilli, and three parts completely arrested it, and that one part per thousand killed the spores of anthrax in ten minutes. Klein's experiments,[1] although confirmatory of the great disinfectant power of corrosive sublimate, required stronger solutions to produce the same results—namely, 1 per cent. to kill the spores in from five to ten minutes, and one per ten thousand the bacilli, but only

[1] *Report of the Medical Officer of the Local Government Board*, 1885.

after thirty minutes' exposure. Lingard has shown that a solution of one part in nine hundred and sixty (the pharmacopœal strength) requires from four to eight hours to kill human tubercle. It is these differences of results in experiments with disinfectants, due to varying conditions, that render it difficult to estimate their true values. Carbolic acid, with which countless experiments have been made, in Koch's hands has lost its high reputation. He found that it required a 1 per cent. solution of phenol to kill anthrax bacilli, and a 5 per cent. solution required more than one day to kill the spores. Hence to be effective, at least 10 per cent. of carbolic acid is requisite, together with prolonged exposure. Schill and Fischer found that it required twenty-four hours for a 5 per cent. solution to destroy the infection of tuberculous sputa. Hence mercuric chloride has largely superseded carbolic acid as an effectual disinfectant; it is usually made by dissolving half an ounce of corrosive sublimate in an ounce of hydrochloric acid and adding three gallons of water. Unfortunately, it is a powerful poison, and is colourless; it is therefore not only necessary to artificially colour and scent it in order to distinguish it,[1] but it also requires to be carefully guarded.

The halogens are employed for practical disinfection in the form of gases in a similar manner to sulphurous and nitrous acid gases. Koch showed that the relative disinfectant effects of the halogens in solution in arresting the development of anthrax bacilli were: iodine, 1 in 5000; bromine, 1 in 1500; and chlorine, 1 in 1500; whilst the spores were destroyed by iodine (1 in 7000) in one day, bromine (2 per cent.) in one to five days, chlorine (fresh made) in one to five days. Dr. Cash,[2] in a number of experiments with the halogens in solution, also found, although the difference was not very decided, that iodine was the best disinfectant, bromine next, and chlorine last; sulphurous acid he considered most valuable in the gaseous form. Iodine in gaseous form being eight and a half times heavier than air, it is impossible to use it in the form of gas on account of the difficulty of diffusion.

[1] The addition of five grains of aniline blue and of one ounce of wood naphtha answer these purposes.

[2] *Report of the Medical Officer of the Local Government Board*, 1886.

Bromine gas was found by Fischer and Proskauer also to diffuse unequally, and to prove variable in its results, although it promised to recommend itself for practical use on account of the facility of generating it by Franck's process—namely, by simply saturating pieces of porous earth (*Kieselguhr*), contained in a bottle, with liquid bromine, and when required for use, removing the stopper and allowing the gas to flow out. The experiments of the same observers with chlorine showed that the power of this gas as a germicide varies proportionately with the humidity present, an excessive volume of chlorine and long exposure is required in a dry atmosphere, whilst in the presence of moisture a less volume and shorter exposure suffice. Whereas a high percentage of chlorine in a dry atmosphere failed to destroy microbes; 1 per cent. in moderate humidity required twenty-four hours, and 0.3 per cent. in an atmosphere saturated with moisture was completely fatal in three hours. The conclusions arrived at by these observers were that at least 1 per cent. of chlorine is necessary to disinfect, that this will require, in order to generate it, about 15½ lbs. of bleaching powder and 22 lbs. of hydrochloric acid per 1000 cubic feet of space, that all surfaces should be previously wetted or moistened by steam or spray, and that chlorine is more effectual than sulphurous acid gas.[1] Koch's experiments on sulphurous acid gas, generated by burning sulphur, proved that bacilli exposed in very thin layers directly to the action of the gas succumbed quickly, that in a saturated atmosphere many hours exposure was necessary, even with large volumes of the gas present, to destroy the weaker organisms, and that under less severe conditions they escaped injury. Spores resisted exposure to 6 per cent. of the gas in a closed box for days.

Disinfection by a chemical agent is a chemical experiment, and requires discrimination and care. The smaller the scale on which it is attempted, and the greater the attention to detail, the more successful the result. Hence in the sick-room of an infected patient attention to detailed destruction of infection is of the utmost importance. It is useless to discharge infected stools into a drain to be followed subsequently by volumes of a disinfectant. If a

[1] *Micro-parasites in Disease.* (New Sydenham Society.)

drain is odoriferous, it is because of wrong construction or of insufficient cleansing or flushing, and the remedy is obvious. If an infected stool is to be discharged into a drain, as in cholera, enteric fever, dysentery, etc., it should be saturated with a reliable germicide, as a strong solution of corrosive sublimate, or of carbolic acid, preferably the former; both are poisonous, and require careful guarding. Other discharges should be similarly treated, while soiled dressings and bandages must be burnt. All soiled linen should be well soaked in the solution of sublimate, or well boiled, before being sent to the wash. The disinfection required varies in different diseases according to the manner in which the infection is thrown off. Broadly speaking, it is convenient to separate them into those diseases communicable directly through the air, and those not so communicable; into the former category fall all the ordinary infectious diseases, and into the latter those specially communicable through the discharges, or through the excreta, as in cholera, typhoid, dysentery, and also puerperal fever. In the latter diseases, if special attention be directed during the progress of the disease to the destruction and disinfection of the discharges or excreta, and also of the linen and other soiled objects, with subsequent steaming of the bedding, general cleansing may be trusted to remove any remaining infection without fumigation.

After those diseases that infect the air and surrounding objects and surfaces, very thorough disinfection of the room and its contents is necessary. These specially include small-pox, diphtheria, scarlatina, typhus, and although not at present generally practised, should embrace measles, whooping cough, infectious pneumonia, and pulmonary consumption. At the second Congress for the study of tuberculosis, held in Paris in 1891, it was concluded that every place in which a person suffering from tuberculosis has died or dwelt should be officially subjected to compulsory disinfection.

Besides the solid objects, all the other contents of the room then require treatment, and in addition the air of the room and the surfaces require disinfection.

This is accomplished by fumigation, by stripping the

paper from the walls and burning it, and by thoroughly washing the ceiling, and all the paint and wood-work. Gaseous disinfectants are used for fumigation, and their relative efficacy as germicides has already been entered into. Every opening, including windows and chimney, must be closed, and the crevices pasted up with paper, so as to render the room as air-tight as possible, leaving only the door of exit to be closed last and pasted up as soon as the fumes commence to evolve.

The penetrative power of gaseous disinfectants is almost nil, and prolonged exposure in actual practice results in proportionate diminution of disinfectant power by escape and diffusion. So that fumigation of a room, even as carefully sealed as possible, is very superficial, and can only be relied upon to disinfect the contained air and the more exposed surfaces. The presence of more or less moisture is necessary to obtain good results, but this under ordinary circumstances is difficult to supply. Complete disinfection of rooms by fumes is therefore impossible, but it is a useful preliminary, as part of the process of purifying the air and the more exposed surfaces, and diminishing the risk to those employed in carrying out further measures, chlorine being most efficacious for the purpose.

Chlorine is most readily produced by adding crude hydrochloric acid to good bleaching powder containing from 35 to 40 per cent. of chlorine. The enormous quantities stated to be necessary by Koch, Fischer, and Proskauer are impracticable, and it is generally held that 1½ lbs. of hydrochloric acid to 1 lb. of bleaching powder per 1000 cubic feet of space is sufficient for this superficial disinfection. As chlorine is a heavy gas, it is necessary to place the powder in several suitable receptacles as high as practicable, then to add to each the required proportion of acid, and to escape from the room as soon as possible.

As an alternative, sulphurous acid gas is also used. It may be generated by simply burning sulphide of carbon, but this is a dangerously inflammable liquid, and if overturned is difficult to extinguish. It is generally produced by burning sulphur in an iron pan, lighting it by means of a little alcohol or wood shavings upon it, the quantity of sulphur used being also 1 lb. per 1000 cubic feet of space.

Whichever gas is used, the room must be rendered air-tight as described. Both gases, but especially chlorine, are liable to injure metals, pictures, and objects of art. Vaseline or varnish may be used to protect them. It is also desirable to precede the fumigation by steaming or spraying the air and the surfaces in order to supply the requisite moisture. The room may be left closed from three to twelve hours or longer; the shorter the time the less the exposure, the longer the time the more diluted the gas becomes by leakage; and the more thorough the after disinfection the more abbreviated may the fumigation be.

After the re-opening and thorough ventilation of the room by open windows, the walls should be stripped of paper, which should be burnt, or if not papered they should be washed, together with the ceiling, the floor and all wood-work and paint-work, with a strong solution of potash or soft soap. Koch found potash soaps to possess considerable power in checking the development of anthrax spores, 200 parts per million retarding, and 1000 parts entirely preventing it. So that, although it is not a true disinfectant, it is a strong antiseptic as well as detergent, and most valuable for cleansing. In Germany spraying of the surfaces with a solution of corrosive sublimate is resorted to in some cases, and is a valuable measure, rubbing down with bread-crumbs having been discarded as an ineffectual, tedious, and expensive process. Doubtless, the most efficient manner of disinfecting the interior of a room is to spray the surfaces with corrosive sublimate solution, and then, in the moisture-laden atmosphere, to fumigate with chlorine.

The disinfection of the clothing, bedding, and stuff furnishings of a room may take place subsequently to the fumigation and cleansing of the interior, or, if care be exercised in their transfer, and a steam chamber be available, at the same time as the fumigation. It should not be done previously, for it is obviously objectionable to return disinfected articles to an infected room. This is one of the difficulties to be practically met in disinfecting the rooms of the poor, and of those whose dwelling accommodation is restricted to one or two rooms. These people must necessarily be turned out of their homes, and, furthermore, their

persons must have become more or less infected by close contact. Some provision should therefore be made to shelter this class during the necessary exclusion from their homes, and means should be provided for the disinfection of their wearing apparel and for the cleansing of their persons, the hair being specially liable to retain infection. The installation of a shelter is therefore a desideratum, and by the Infectious Disease (Prevention) Act of 1890, the duty is cast upon local authorities to make such provision, together with the necessary attendance. Such a structure, besides providing the necessary waiting-rooms, might advantageously contain dressing-rooms and douche baths, for the purpose of cleansing the person and enabling the wearing apparel to be passed through the disinfecting chamber.

A complete disinfecting station would therefore consist not only of the disinfecting chamber, with a room on both sides, the destructor furnace, and the stable and coach-house, but also have attached to it waiting-rooms, dressing-rooms, and douches. The infectious dead would more appropriately be consigned to a mortuary set apart for infectious cases, and attached to the mortuary for public use.

CHAPTER V.

INOCULATION AND VACCINATION.

The processes of inoculation and vaccination were first practised as a defence against small-pox, although it is now recognised that immunity against certain other diseases may be procured by the inoculation of the attenuated virus of the diseases. Jenner's observations and empirical work have been confirmed in principle by the experiments and rational deductions of Pasteur and other observers in other diseases. The searching criticisms of vaccination cannot, however, be met by generalisations, but at the risk of being tedious statistical figures must be appealed to.

There is evidence from the remote past that in the East it was observed that an attack of at least one disease—namely, small-pox—conferred protection against a future attack. It was also known that this disease could be communicated by inoculation. Furthermore, it was known that the disease, when communicated by artificial inoculation under favourable conditions, ran a more benign course than when acquired by infection. Artificial inoculation was a very ancient practice in Africa, Persia, and China. It was introduced into Constantinople in 1673, and in 1717 into England by Lady Mary Wortley Montague. Quite apart from the fact that inoculation tended to spread the disease, it must have been apparent in the earliest times that the mortality from the disease, when inoculated, was appreciably less than from the disease acquired by infection. The protection afforded by the inoculation of a more or less attenuated virus is therefore a fact derived from the remotest antiquity, and confirmed by centuries of human experience.

Dr. Guy,[1] speaking of this country in the last century, says that, estimating the small-pox mortality as 1 in 5, the inoculated disease at the outset was 1 in 50, and this was ultimately reduced by careful precautions to 1 in 500. But although the mortality from inoculated small-pox was reduced to small proportions, those inoculated became centres for the spread of the disease; the attenuated virus, although robbed of its fatality, was not deprived of its infectious power.

Jenner called cow-pox *variolæ vaccinæ*, and believed it to be small-pox modified by transmission through the cow. This belief was also expressed by Sir John Simon and Dr. Cory in evidence before the Royal Commission on Vaccination still sitting. Many experiments have been made to inoculate cows with small-pox, but with small success. Numerous experimenters have failed, notably Chauveau, whilst Ceely and Badcock succeeded only in a few instances. Voigt, chief public vaccinator at Hamburg, has succeeded by vaccinating a calf in one place, and inoculating small-pox in another part of the body, in producing true vaccine vesicles, and in an exceptional case he was able to carry on vaccination through a series of calves, and then through human subjects, but these experiments have not yet been confirmed by other observers.[2] It is a curious coincidence that the occurrence of cow-pox amongst cows should be less frequent since small-pox in man has become less prevalent, and it has been held that, as only female cattle suffer, and milch-cows only have the eruption upon the teats and udders, the hands of milkers are the means of inoculation.

Whether vaccinia be human small-pox transmitted to the cow, or whether it be a distinct disease peculiar to ruminants, it closely resembles modified variola, but without the infectious properties of that disease. If, on the one hand, vaccinia be enfeebled small-pox, robbed of its infec-

1 *Public Health.*

2 Dr. Hime, of Bradford, has recently recorded the "successful transformation of small-pox into cow-pox" in the *British Medical Journal*, 16th July 1892; and Surgeon-General Cornish, in the following number of the same journal, has called attention to a similar successful experiment by Surgeon Major King in India.

tive properties, it is a typical example of the protective power of an attenuated inoculation; if, on the other, it be a separate and distinct disease, it is a typical example of the inoculation of one disease protecting against the attacks of another and similar disease. That the protective power exists can be proved up to the hilt.

Brigade-Surgeon Pringle, in a paper upon vaccination read before the Epidemiological Society in 1891, not only stated that he had seen in India series of selected inoculations of small-pox virus in which the attenuation reached a point at which there was no general eruption, and the local phenomena were scarcely distinguishable from those of vaccination, but he also quoted a curious passage from an ancient Hindu work: "The small-pox produced from *the udder of the cow* will be of the same mild nature as the original disease . . . there will be only a slight fever of one, two, or three days, but no fear need be entertained of small-pox so long as life endures."

Sir Thomas Watson expressed the opinion that there is no contagion so strong and sure as that of small-pox, and none that operates at so great a distance. The observations of Power, Bertillon, and others go far to prove that small-pox may be diffused aërially to a distance of thousands of feet, if not yards. Sir John Simon, in his papers upon the "History and Practice of Vaccination," says of small-pox that it seizes, with very few exceptions, on all who for the first time come within its range, and he gives many historical quotations of its fearful ravages and mortality amongst remote and isolated populations in uncivilised and civilised communities. These papers are also appended *in extenso* to the First Report of the Royal Commission on Vaccination, 1889, and the following table of the comparative mortality of small-pox before and since the introduction of vaccination is extracted from that source:—

Terms of years respecting which particulars are given.	Territory.	Approximate average annual death-rate by small-pox per million of living population.	
		Before introduction of vaccination.	After introduction of vaccination.
1777-1806 and 1807-1850	Austria (Lower)	2,484	340
,, ,, ,,	Austria (Upper) and Salzburg	1,421	501
,, ,, ,,	Styria	1,052	446
,, ,, ,,	Illyria	518	244
,, ,, 1838-1850	Trieste	14,046	182
1777-1803 and 1807-1850	Tyrol and Voralberg	911	170
1777-1806 ,, ,,	Bohemia	2,174	215
,, ,, ,,	Moravia	5,402	255
,, ,, ,,	Silesia (Austrian)	5,812	198
,, ,, ,,	Gallicia	1,194	676
1787-1806 ,, ,,	Bukowina	3,527	516
1776-1780 and 1810-1850	Prussia (Eastern Provinces)	321	56
,, ,, ,,	Brandenburg	2,181	181
,, ,, 1816-1850	Westphalia	2,643	114
,, ,, ,,	Rhenish Provinces	908	90
1781-1805 and 1810-1850	Berlin	3,422	176
1776-1780 and 1816-1850	Saxony (Prussian)	719	170
1774-1801 and 1810-1850	Sweden	2,050	158
1751-1800 and 1801-1850	Copenhagen	3,128	286

Dr. Parke, the medical officer of Stanley's African Relief Expedition, stated in evidence before the Royal Commission, that of the 250 men of his party who were exposed to an epidemic of small-pox, all were either vaccinated or were already protected by a previous attack. Of these men four had mild attacks, three recovered, the fourth committed suicide. Of about three hundred carriers sent by Tippoo Tib, and who had never been vaccinated, nearly all were attacked, and the villages were filled with bodies, the men dying in great numbers. After the epidemic several of those men that Dr. Parke had vaccinated came and said it was good medicine he had given them; apparently the coast

people learnt the benefit of vaccination, the Nubians voluntarily submitting to it.

Dr. Havelock Sturge, in describing an epidemic of small-pox among Kafirs in the Transkei in 1888,[1] says: "I have no single note of an unvaccinated person enclosed in a quarantine line escaping the disease; while, on the other hand, the numerous instances, occurring during many months, of vaccinated people being enclosed with those dying of the pest, and yet escaping all illness, opened the eyes of the savages to the value of Jenner's discovery." Brigade-Surgeon Pringle, who had twenty years' experience in India, told the writer that when vaccination was first introduced into the native states under his supervision, the female children were subjected in greater number to the rite than the male, but the proportion was reversed as soon as the natives by experience found that the unvaccinated male children (which they prize more) succumbed more readily to small-pox than the vaccinated females.

Dr. Neve, of the Mission Hospital in Cashmere, in a letter addressed to the *Civil and Military Gazette* of Lahore in 1884, stated that Cashmere was an entirely unprotected country. He obtained a statement of the mortality from small-pox among the immediate relatives of the hospital staff. They represented twenty-five families, and in these a hundred and ninety members were born, of whom exactly one hundred died of small-pox. Two or three children had not at the moment yet been attacked, but all the others had had the disease—that is, 95 per cent. were attacked, and 55 per cent. succumbed.

Archdeacon Farler, of Magila, in 1887, wrote to the Universities Mission—"We have just saved the whole district of Magila from an invasion of small-pox, vaccinating everybody at the rate of about fifty a day, until all have been vaccinated, so that while other districts have suffered considerably around us, there has not been a single case of small-pox in the Magila district, with its hundreds of villages and thousands of people. This, of course, has commended our medical science to the people, and they come in numbers."

The strong prejudices and superstitions of primitive races

[1] *Brit. Med. Journ.*, 1889.

have been overcome rapidly by ocular demonstration of the security against small-pox afforded by vaccination. A disbelief in this security could only arise in countries, the inhabitants of which are totally unfamiliar with the fearful rapidity and extent of the spread of small-pox, and the terrible mortality accompanying it in a susceptible community.

The diagram illustrating the table of burials within the London Bills of Mortality appended to the Second Report of the Royal Commission on Vaccination, 1890, and handed in by Dr. Creighton, an adverse witness, graphically depicts the difference in the epidemicity of small-pox in this century and the hundred and fifty years preceding it. Whereas for one hundred and fifty years in London the mortality from small-pox displayed well-marked maxima and minima at short intervals of every few years, with the advent of this century these periodical fluctuations almost entirely disappeared, coincidently with a general fall in the mortality, and this period corresponds with the introduction of vaccination.

Dr. McVail, in his inquiry into the prevalence of small-pox in Kilmarnock from 1728 to 1764, clearly revealed the periodicity, age-incidence, and fatality of small-pox in the last century. The conclusions he arrived at were that small-pox was *epidemic* in Kilmarnock *every four and a quarter years;* that the death-rate at all ages was twenty times, and under five years of age thirty-five times, greater than at the present day; that the mean age at death was two and a half years, whereas now it is nearly twenty years; that the death-rate in the second six months of life was nearly five times as great as in the first, whereas now it is four times less in the second than in the first six months; and that the small-pox death-rate has improved about twelve times as fast as the death-rate from measles, whooping cough, and fevers.[1]

The Registrar-General in his Forty-third Annual Report shows the changes that have taken place in small-pox mortality coincident with the progress of vaccination since 1847:—

[1] See also Dr. Lovell Hunter's paper on small-pox mortality in Pudsey a century ago, *British Medical Journal*, 27th August 1892.

MEAN ANNUAL DEATHS FROM SMALL-POX PER MILLION LIVING AT SUCCESSIVE AGE-PERIODS.

	All Ages.	0-5.	5-10.	10-15.	15-25.	25-45.	45 and upwards.
1. Vaccination optional (1847-53)......	305	1617	337	94	109	66	22
2. Vaccination obligatory, but not efficiently enforced (1854-71)	223	817	243	88	163	131	52
3. Vaccination obligatory, and more efficiently enforced by Vaccination Officers (1872-80)	156	323	186	98	173	141	58

These figures show that a steady decline in small-pox mortality at all ages has taken place; that the decline has been confined entirely to the age-periods 0-5 and 5-10, in the first of which periods it has fallen 80 per cent.; that the mortality in the 10-15 group has remained stationary; whereas in the later age-periods it has increased, the increase becoming greater the more advanced the time of life. That this decline is not appreciably due to improved sanitation is seen in the comparison of the mortality from small-pox with that from all other causes.

DEATH-RATES IN 1872-80, COMPARED WITH THOSE IN 1847-53, THE LATTER TAKEN AS 100.

	All Ages.	0-5.	5-10.	10-15.	15-25.	25-45.	Over 45.
Small-pox	51	20	55	104	159	214	264
All other causes	93	94	70	67	71	88	97

The Registrar-General carefully weighs the reasons for the inversion of the incidence of small-pox mortality upon early and later age-periods:—

"It is pretty generally recognised, and this on good grounds, that the immunity derived from vaccination is both less perfect and less permanent than that conferred by small-pox itself; its efficacy diminishing with the lapse of time, while the protective influence of small-pox remains

practically unaltered. . . . Before vaccination came into use, few persons escaped having small-pox at some time or other in their lives. The great majority had it when young, and of these a large proportion died, causing a very high death-rate in the earlier age-periods. But those who survived the attack enjoyed a practically complete immunity for the rest of their lives, and as they formed a considerable proportion of the population at the later age-periods, the small-pox death-rates at these later periods of life were very low. But when vaccination came into use, and in proportion as its use became more and more general, the relative conditions of the different age-periods as regards immunity were materially altered, and partially inverted. Childhood, previously altogether unprotected, now received a very considerable immunity; while the later ages, previously much protected, now had their immunity considerably diminished, and the more so, the later the period of life and the more remote therefore the date of vaccination."

The inversion of the incidence of mortality at early and later age-periods is still more marked in a table given by Buchanan in the Fourteenth Report of the Medical Officer to the Local Government Board:—

CONTRIBUTION OF VARIOUS AGES TO 1000 SMALL-POX DEATHS AT ALL AGES.

Ages at Death.	Geneva, 1580-1760.	Kilmarnock, 1728-1764.	London, 1881.		
			Total Inhabitants.	Unvaccinated Community.	Vaccinated Community.
0-10	961	988	343	612	86
10-20	26½	5	170	146	173
20-30	10	7	213	108	319
30-40	2½	—	142	72	221
40 & upwards		—	132	62	201
Total	1000	1000	1000	1000	1000

The marked protection during the first ten years of life afforded by vaccination in infancy is further illustrated by the unimpugned statistics of the small-pox epidemic in Chemnitz, 1870-71, laid before the Royal Commission by

Hopkirk. Of the 64,255 inhabitants of Chemnitz in 1870-71, 53,891, or 83.87 per cent., were vaccinated; 5,712, or 8.89 per cent., were unvaccinated; and 4,652 had already had the small-pox. The numbers of attacks and of deaths under ten years of age, which speak for themselves, are given below:—

Age.	Vaccinated.			Unvaccinated.		
	Cases.	Deaths.	Mortality per cent.	Cases.	Deaths.	Mortality per cent.
1st year	8	—	—	373	102	27.3
2nd ,,	15	—	—	528	51	9.6
3rd ,,	30	—	—	444	26	5.9
4th ,,	31	—	—	331	29	6.3
5th ,,	43	—	—	222	9	4.0
6th ,,	35	—	—	197	7	3.6
7th ,,	46	—	—	105	1	0.9
8th ,,	28	—	—	98	2	2.0
9th ,,	18	—	—	71	1	1.4
10th ,,	15	—	—	71	0	0.0
Total under 10 ..	265	—	—	2440	220	9.0

If the death-rate of vaccinated children under ten in Sheffield during the epidemic of 1887-88 had been at the same rate as that of the unvaccinated, there would have been 4400 deaths, whereas there were only 9 such deaths —a most striking result.

The Registrar-General's Fifty-first Annual Report not only records the greater mortality of small-pox amongst males than females, due doubtless to the greater susceptibility of males to attack as well as less resistance to a fatal issue, but also the incidence of mortality upon infants during sub-periods of the first year of life. The proportion of infants per million per annum dying of small-pox since 1852 has been, during the first three months of life, 1573; during the next three months, 890; during the next six months, 790; during the second year the rate has fallen again nearly one-half, and has continued to fall until it reached its minimum in the 10-15 years age-period. The protection by vaccination is comparatively small in the first

three months, which is practically a pre-vaccination period, but increases with the advance of age until puberty. Another interesting fact is evinced by the mortality of erysipelas, which has been per million per annum, during the first three months of life, 1905; during the next three months, 774; and during the next months, 268. This is not compatible with an opinion that the mortality of infants from erysipelas is due largely to vaccination, since the excess is greatest at the pre-vaccination age, and rapidly diminishes during the vaccination period.

The quality of the vaccination is as important a factor as the lapse of time in the relative protection afforded against small-pox. It is observed generally, in those diseases in which one attack renders the sufferer more or less immune against a subsequent attack, that the severity of the recurrence is more or less in inverse proportion to the greater or less severity of the previous attack. This would appear to be the case also with artificial inoculations and vaccinations generally, but in a modified degree, and with occasional exceptions. The fact is borne out in small-pox by statistical records.

FATALITY PER CENT. OF ATTACKS ACCORDING TO QUALITY OF VACCINATION AND AGE OF PATIENTS, BASED UPON 10,403 CASES OF SMALL-POX, BY DR. GAYTON, 1885.

At Ages.	Vaccinated, or said to have been Vaccinated.			Not Vaccinated.
	Marks. Good.	Marks. Imperfect.	Marks. Invisible.	
0-5	0.0	11.5	39.8	56.5
5-10	0.9	5.0	19.3	35.2
10-15	1.1	3.4	19.6	23.3
15-20	1.9	6.3	19.0	42.1
20-30	3.9	13.1	32.1	49.8
30-40	9.5	14.8	35.0	40.7
40 and over	12.5	19.1	33.5	43.0

Marson's well-known figures are based upon 13,755 cases of post-vaccinal small-pox, extending over a period of twenty years.

Cases of Small-pox classified according to the Vaccination marks borne by each patient.	Percentage of Deaths in each Class.	
	1836-51. 3,094 cases	1852-67. 10,661 cases
Unvaccinated	35.5	34.9
Stated to have been vaccinated, but no cicatrix	21.7	39.4
Having one vaccine cicatrix	7.6	13.8
Having two vaccine cicatrices	4.3	7.7
Having three vaccine cicatrices	1.8	3.0
Having four or more vaccine cicatrices ...	0.7	0.9

Mr. Sweeting, medical superintendent of the Western Hospital of the Metropolitan Asylums Board, handed in to the Royal Commission an analysis of 2584 cases admitted during the years 1880-85, showing the number of cases according to quality of vaccination and severity of small-pox attacks.

Vaccination.	Number of Mild Cases.	Number of Severe Cases.	Percentage proportion of mild cases to the total number.
Good	35	4	89.71
Imperfect	1497	424	77.92
Doubtful	62	204	23.30
Unvaccinated	29	329	8.10
Totals	1,623	961	62.80

Dr. Barry, in his report upon the Sheffield epidemic of 1887-88, gives similar figures, from the Sheffield Hospitals, as to the proportion of mild and severe cases according to the quality of vaccination.

Condition as to Vaccination.	Number of Cases of each type.		Proportion per cent. of mild to total number.
	Varioloid and Discrete.	Coherent and Confluent.	
Vaccinated	1075	223	82.8
Unvaccinated	82	361	18.5

Unfortunately, no compulsory standard of vaccination is fixed. The antipathy of sensitive mothers leads not

infrequently in private to reducing the number of insertions and of the cicatrical area, and occasionally after the failure of a tentative abrasion to so-called insusceptibility. Insusceptibility to primary vaccination, in the opinion of skilful operators, does not exist, and by expertness the process may be rendered so simple, rapid, and painless, as to leave little impression upon the sensibilities. The credit of vaccination would be enhanced by making it compulsory to certify the number of successful vesicles and the area covered by them, limiting them to a minimum of five in number, or to two-thirds of a square inch in total area, in primary vaccinations.

The German Vaccination Commission of 1884, after full inquiry, reported to the German Government the conclusions arrived at in reference to small-pox, vaccination, and re-vaccination, and regard is due to the opinions of the eminent authorities on that Commission. With rare exceptions, one attack of small-pox confers upon the survivor immunity against a future attack. Vaccination exerts a similar protection, but the duration of the immunity varies, being on an average about ten years; at least two well-developed vesicles are necessary to effect this, and re-vaccination is necessary ten years after the primary vaccination. The protection conferred upon the individual is relatively increased in proportion to the well-vaccinated condition of the surrounding community, and thus vaccination is protective, not only individually, but generally, against small-pox. The benefits of vaccination immensely outweigh the possible injuries. The danger of transferring syphilis in human lymph is extremely slight, although admissible. Accidental disease of vaccination wounds may take place as in wounds from other causes. By proper precautions such dangers may be reduced to a minimum, and no provable increase of any particular disease has taken place as the consequence of vaccination. Nevertheless, the Commission recommended the gradual supercession of human lymph by animal lymph. But the most interesting fact brought out by the Commission was the effect of compulsory re-vaccination. Some of the statistics (with additions) proving the value of this measure are here reproduced.

MORTALITY FROM SMALL-POX PER 100,000 LIVING.

	Prussian Army.	Austrian Army.	Austria.	England.	Prussia.	Berlin.	London.	Vienna.
1870	0.08 33.32	17.28	35.18	11.6	17.52	22.37	30.20	46.71
1871	27.67	40.1	30.30	101.5	243.21	632.56	242.16	74.90
1872	5.65	101.4	189.99	82.4	262.37	132.61	53.80	536.98
1873	2.68	108.0	823.36	10.1	35.65	11.21	3.55	228.50
1874	0.33	67.0	178.19	9.1	9.52	2.47	1.66	135.26
					Re-vaccination compulsory.			
1875	0.0	21.5	57.73	4.0	3.60	5.19	1.32	113.50
1876	0.0	10.4	39.28	10.3	3.44	1.81	20.80	167.80
1877	0.0	25.5	16.94	17.8	0.34	0.40	70.98	84.01
1878	0.0	15.4	5.57	7.9	0.71	0.78	38.81	75.91
1879	0.0	22.7	50.88	2.5	1.26	0.75	12.13	46.91
1880	0.0		64.27	2.9	2.60	0.81	12.50	73.52
1881	0.0		78.80	12.4	3.62	4.74	61.91	123.95
1882	0.0			5.4	3.64	0.43	11.07	108.29
1883				3.9	4.00	0.33	3.00	9.6
1884				8.7	1.5			
1885				10.7	1.4			
1886				1.3	0.5			

The statistics of Hamburg, Breslau, Munich, and Dresden, where the German compulsory re-vaccination law has also been in force since 1875, all show the same permanent decline in small-pox mortality as those of Berlin.

At the Highgate Small-pox Hospital it has been the rule during more than fifty years for the nurses, attendants, and servants to be re-vaccinated before commencing their duties, and none have ever been known to take small-pox at this institution. Furthermore, those few cases in which nurses at other small-pox hospitals have taken the disease have been due to the fact that the re-vaccination was not completed before commencing duty.

The late Paul Bert, the physiologist and minister, was so impressed with the value of re-vaccination, that he had himself re-vaccinated when at Havre, and, in order to put the question to the test, he was subsequently inoculated with virus from a man dying of small-pox, and escaped the disease.[1]

[1] *Brit. Med. Journ.*, 1886.

The effects of vaccination and re-vaccination upon the attack-rate and death-rate from small-pox, during an epidemic in a large urban community, are also well illustrated in the report to the Local Government Board by Dr. Barry, on the small-pox epidemic of 1887-88 at Sheffield. The following were the attack- and death-rates per thousand living at each of the age-divisions given :—

Ages.	Attack-rate.			Death-rate.		
	Unvaccinated.	Once Vaccinated.	Twice Vaccinated.	Unvaccinated.	Once Vaccinated.	Twice Vaccinated.
Under 10....	101	5	—	44	0.09	—
Over 10......	94	19	3	51	1	0.08

Buchanan summarises the results thus: the children vaccinated had, as compared with the unvaccinated, a 20-fold immunity from attack, and a 480-fold security against death from small-pox; the persons over 10 years of age, once vaccinated, had a 5-fold immunity against attack, and a 51-fold security against death; and the twice vaccinated, a 31-fold immunity from attack, and a 640-fold security against death.

We may conclude, therefore, that natural insusceptibility to small-pox practically does not exist, that the contagion is so far-reaching, so readily attacks indiscriminately the unprotected, and is so fatal, that in a community *entirely* unprotected either by previous small-pox, inoculation, or vaccination, an epidemic causes an enormous mortality; that the disease leaves the survivors disfigured, maimed, or weakly, but protected more or less against future attack, so that the disease continues to fall only upon the unprotected—namely, the newly born and infant population, the few survivors of which remain protected for a number of years.

Vaccination protects the infant and the young population in proportion to the number vaccinated, and the quality and quantity of the vaccination marks; but the protective influence of vaccination fades sooner than that of an attack of the disease, so that in later years susceptibility to small-pox returns. Re-vaccination compensates for the lesser duration

of immunity, and practically brings artificial immunity to a protective level equal to a previous attack of the disease, so that periodical re-vaccination almost entirely averts small-pox. The dangers of vaccination are infinitesimal, but, such as they are, may be avoided by the use of animal lymph and careful precautions, so that only the mischances common to any abrasion remain.

In reference to the mischances that may occasionally follow upon vaccination through want of care and by neglect, it is extraordinary, considering the immense number of vaccinations performed, that they should be so few, and speaks highly for the caution exercised in the operation. Unfortunately, operators cannot control the frequent mismanagement and amateur doctoring of the punctures by ignorant mothers and nurses. The objections that may be raised to humanised lymph, however, although founded on slender bases, may be overcome by the use of animal lymph.

The German Commission of 1884, whilst definitely recommending that human lymph should be superseded by animal lymph, advised the gradual establishment of institutions for providing supplies. The great advantage of the use of calf lymph is that it sweeps away any suspicion of the inoculation of other diseases. Syphilis cannot be communicated to animals, and, even if it could be, the vaccination from calf to arm, and calf to calf, and the absence of vaccination from arm to calf, would afford no opportunity. Animal diseases may be eliminated by careful selection, and subjecting the calves to quarantine of observation in healthy stalls previous to vaccinating them. Wound diseases may be avoided by washing the calf vesicles and instruments with an antiseptic solution previous to taking the lymph. Then, any post-vaccinal erysipelas or skin eruptions, other than those peculiar to vaccination, cannot possibly be attributed to vaccination as the cause.

A further advantage is that large supplies may be obtained; one calf may be made to yield sufficient lymph for four or five hundred vaccinations, with perfect uniformity of character, and the lymph may be easily submitted to test inoculation. The only drawback is the increased cost, due to the use of calves, the wider accommodation

required, and the greater skill necessary in parts of the process. Practically the success of vaccination from calf to arm with animal lymph is identical with that of vaccination from arm to arm with humanised lymph, and the resulting vesicles are identical in appearance. The vaccine vesicles in the human subject yield the fittest lymph on the eighth day, but on account of the normal temperature of the calf being a degree or more higher than that of man, they are matured by the fifth day in the calf. This necessitates a tri-weekly instead of a weekly service, a calf vaccinated on Monday maturing on Friday, that vaccinated on Friday maturing on Wednesday, and that again on Wednesday maturing on Monday. This holds good for the calf to calf perpetuation of the stock lymph, but the arm vesicles mature, as in arm to arm vaccination, on the following day week, for inspection by the operator.

Dr. Cory, the director of the animal vaccine station of the Local Government Board, in his evidence before the Royal Commission, states that, from 1882 to 1889, 32,002 vaccinations with calf lymph were performed at the station in Lamb's Conduit Street, and that only eight deaths were reported to the station. The first child died six days after the date of vaccination from convulsions, which may have been due to many causes. The second died fourteen days after from confluent small-pox, caught probably ten days before vaccination, and therefore before immunity had been obtained. The third child was loosely said to have died from vaccination two months after the operation, cause not stated. The fourth died of inflammation of the bowels six days subsequently. The fifth succumbed to cellulitis six weeks after vaccination; this may possibly have been consequent on vaccination. Convulsions was the cause of the sixth death, a week after. The seventh died three weeks and two days after vaccination, from erysipelas. The eighth and last death took place from convulsions nineteen days subsequently. So that out of over 32,000 cases only two of the subsequent deaths could reasonably be attributed to vaccination—namely, the two cases of wound-disease, cellulitis and erysipelas. This mortality is probably not even so high as that resulting from common cuts and scratches.

The mass of evidence confirming the protective power of vaccination and re-vaccination is irresistible, and the opposition to it is due fundamentally to the objection to compulsion. The objects of compulsion are to insure that the largest percentage possible of the population shall be protected for the benefit of the whole community, to secure a regular and sufficient supply of lymph, to prevent undue haste, and insufficiency, inferiority, or failure of lymph in times of panic. The abolition of compulsion would mean the neglect of vaccination and the accumulation of unprotected persons in a community, so that in the panic produced by an epidemic, vaccination would be overtaxed with injurious results, and lymph would fail to supply the demand for vaccinations and re-vaccinations. The ignorant and improvident neglect vaccination, as they do other prudent measures that bear remote rather than immediate results, until driven by fear into a state of mind ready to seek any alternatives to disease and death, be they good, bad, or indifferent.

Notification, isolation, and disinfection have been advanced by opponents as alternatives, rather than as supplementary measures, to vaccination. Such measures must necessarily break down unless the staff be protected by vaccination and re-vaccination; but this is an admission of the protective power of vaccination, since it cannot be advanced that the staff should be subjected to small-pox to protect them, or that small-pox is desirable at all. Even with a protected staff the entrance of small-pox at a sufficient number of points into a community totally unprotected by vaccination would soon swamp a system of notification, isolation, and disinfection. Into such a community, surrounded by a population protected by vaccination, few cases can be imported, so that even such a system is dependent for its success upon vaccination.

Furthermore, an unprotected individual moving out of this encircled community would run a serious risk, and this risk would increase the farther he travelled from more or less protected districts and countries; he would be almost certain to contract the disease should he reach uncivilised lands, especially the wilder parts of Africa. It is not necessary to go so far afield to prove the fact; a small-pox

hospital at home would suffice if the opponents of vaccination had any desire to try the cxperiment.

The evidence so far leads to the conclusion that the best defence of a community against small-pox is furnished by the following measures:—The alternative choice of humanised or calf lymph for vaccination; compulsory primary vaccination in infancy, producing at least five vesicles of half (preferably two-thirds) a square inch in total area; compulsory re-vaccination before puberty;—these measures to be applicable to the whole community. To this must be added the compulsory re-vaccination of all officers, nurses, and attendants engaged in contact with small-pox. Such small-pox cases as may be imported, or may occur, to be isolated in hospital; disinfection of the room previously occupied by the patient, and of its contents, to be carefully carried out; and the re-vaccination of those that have previously been in contact with the patient, rendering retrogression to quarantine measures unnecessary.

Compulsory vaccination and re-vaccination is the most simple, quick, and equitable manner of enforcing protection against small-pox. The last reminiscence of pauperism clinging to it would be removed if the administration in this country were transferred from the Guardians of the Poor to the Sanitary Authorities. If compulsory vaccination were abolished popular opinion would enforce compulsion in other forms, by compulsory isolation in hospital and by quarantine, as at Leicester, and by completely surrounding the individual by indirect compulsion. There is no escape from compulsion, either in a direct or an indirect manner, except by proving vaccination futile; but if its efficacy be established, its abolition would be suicidal. If the unvaccinated opponents of vaccination were as ready to stake their existence upon the futility of vaccination as many vaccinated advocates of vaccination in small-pox hospitals do continuously stake theirs upon its efficacy, a convincing proof might be afforded of their sincerity.

Small-pox, however, is now not the only disease in which preventive inoculation is practised. The special discovery of Jenner has been extended to a generalisation by the discoveries of Pasteur that the contagia of certain communicable diseases may be attenuated, and that the inocu-

lation of attenuated virus may be employed to procure immunity against virulent forms of these diseases. By analogy, we may infer that various forms of virus are capable of being attenuated, and that virulent types of diseases, in which a previous attack confers immunity, may be warded off by inoculation, although the methods of securing these results may not yet have been ascertained. In not a few animal diseases it has been accomplished; in the human subject the process has only been applied in small-pox, and attempted in yellow fever and cholera.[1] The present ardent research into the causes and methods of producing immunity is but part of the same question under another aspect, which promises to shed a flood of light upon the pathological effects of inoculations.

The experiments into the processes of immunity against human diseases have scarcely yet reached a stage in which it is possible to record general agreement. The subject is in the throes of disputation, but through all the diversities of results there runs not only a possibility but a strong probability of ultimately establishing the fact that, having isolated the microphytes of certain diseases, means will be found of attenuating the organisms or their products to such a degree that they may be inoculated with little risk, and confer immunity against the diseases of which they are the *causa causans.*

Domingo Freire, of Rio Janeiro, states that he has succeeded in obtaining a protective vaccine by cultivating the bacteria of yellow fever through several generations; that several thousands of persons have been inoculated with the vaccine, producing modified yellow fever with a very small death-rate, the patients being rendered immune; and that the Government has now been induced to open an institute for the purpose at Rio Janeiro. The vaccinations are carried out with the attenuated cultures of a microbe which he considers the pathogenic agent of the disease, and the number of vaccinations has been as follows:—

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[1] Recently Hericourt and Richet have communicated to the French Academy of Sciences an account of successful experiments by which they have succeeded, without pathological disturbance, in vaccinating dogs and monkeys against human tuberculosis by means of tubercular cultures derived from birds.

1883-1884	... ...	418
1884-1885	... ...	3,051
1885-1886	... ...	3,473
1888-1889	... ...	3,576
1889-1890	... ...	363
		10,881

He states that the total number of deaths among those vaccinated has been scarcely 0.4 per cent. The vaccinations are gratuitous. Since the introduction of preventive inoculations the disease is less prevalent in working quarters, where formerly it committed great ravages. Whilst still urging the necessity for quarantine, isolation, and disinfection, he claims that these measures are far from being as effectually protective as the inoculations. His experiments have not been authentically confirmed, nor his statistics checked.

It is only necessary to mention here the efforts that have been made to perform preventive inoculations against cholera, in order to introduce a word of caution in accepting unverified and unconfirmed statements. Dr. Ferran, during the cholera epidemic in Spain in 1885, carried on a remunerative practice by performing what were claimed to be preventive inoculations against cholera. A French Commission, of which Professor Brouardel was the chief, was sent in the same year to inquire fully into the processes adopted. Dr. Ferran refused to divulge his methods, and the Commission being unfavourably impressed during their visit to his laboratory, reported that scientific experiment had evidently been sacrificed too soon to so-called practice. Dr. Van Ermengein, sent by the Belgian Government for the same purpose, reported in an equally unfavourable manner. A subsequent outbreak of cholera at Cambrils proved not only the inefficacy of the inoculations, but led to disastrous accidents.

Inoculations must be distinguished as preventive and curative, the former protecting against attack by disease, and the latter protecting against a fatal issue after infection. It has long been known that the incubation stage of small-pox averages about twelve days, and that vaccination matures in eight, so that by vaccination, even after infection, provided the vesicles mature before the acute symptoms set

in, small-pox may be caused to run a modified course. The two other diseases in which curative inoculations have been practised upon the human subject are rabies and tuberculosis.

The micro-organism of rabies has not been discovered, and consequently M. Pasteur adopted a different procedure in attenuating the rabic virus from that followed in the case of fowl-cholera, the microphyte of which he isolated and cultivated pure. By introducing the rabid virus under the dura mater of rabbits, and suspending the virulent spinal cords of the rabid rabbits in flasks in dry air, he succeeded in obtaining an attenuated virus. After numerous experiments upon dogs, he ascertained the length of time necessary to enfeeble the virus to a degree at which the marrow of the cords might be inoculated, and avert a fatal issue of rabies previously communicated. Subsequently, in 1885, inoculations were commenced upon persons bitten by rabid animals, and the success of the treatment led to its further extension. The English Commission and many other scientific inquirers have reported in a convincing manner the efficacy of the procedure, and there are at present more than twenty institutions throughout the world carrying out Pasteur's treatment.

Previous to the introduction of anti-rabic inoculations the mortality amongst persons bitten by rabid animals averaged 15.9 per cent. Since the introduction of the inoculations the mortality has fallen to 1.07 or 0.75, according to whether the original simple consecutive inoculation method, commencing with very feeble virus, was followed, or the more rapid intensive method, in which the first inoculations were made with less feeble virus, and the injection of the most virulent matter reached in a shorter period. The mortality of persons bitten about the face and head, formerly 80 to 88 per cent., is now reduced to 3.84 or 1.82 per cent., according to the method pursued. The deaths occurring in the first fifteen days after bites, when the treatment could not be completed on account of the delay, are omitted from these figures.[1]

The more recent remedy of Koch's for tuberculosis is less decidedly accepted. The inoculation of the glycerine extract

[1] *Encyclopédie d'Hygiène*, tome i.

of pure cultivations of the tubercle bacillus discovered by him, although displaying remarkable results, has not realised the expectations at first raised. The local inflammation, fever, and general constitutional disturbance produced, although beneficial in a certain proportion of cases, are sometimes attended with immediate ill effects, and occasionally produce remote and unexpected results. The extract, according to Dr. William Hunter,[1] is of complex composition and subject to modifications and changes. Until further research has thrown more light upon the possibilities of the remedy, the definite indications as to its application remain in abeyance.

Meanwhile, the febrile reaction produced by the injection of Koch's tuberculin into suspected animals promised to afford a ready means of diagnosing the disease in obscure cases, but the results obtained by many observers up to the present time are contradictory, and the matter is still *sub judice*.

In animals preventive inoculations, especially in France under Pasteur's influence, have been carried out practically on a large scale. Inoculations against chicken-cholera have reduced the mortality from 10 to 1 per cent.; against anthrax, from 10 to $\frac{1}{4}$ per cent. amongst the inoculated; and in black-quarter, or symptomatic anthrax, a considerable reduction in the mortality has also been effected. It is also being practised in swine-fever or hog-cholera, and in pleuro-pneumonia with the same object.

[1] *British Medical Journal*, 25th July, 1891.

CHAPTER VI.

PROTECTION OF ANIMALS AND ANIMAL FOOD.

To prevent the importation of epizootics by foreign live animals it is possible to resort to measures far more heroic, and capable of more stringent enforcement, than any methods applicable to human beings. Quarantine or observation and detention of animals intended for exhibition or re-shipment, or for other special purposes, may be necessary in certain cases, but its practice on a large scale must be limited by space and other considerations. For the bulk of imported animals it may be rendered unnecessary by the slaughter of infected animals at the port of arrival, or by the total exclusion of suspected live animals. In neither case, provided the flesh be good, is the importation of food thereby hindered.

It appears to have been in 1848 that the English legislature first made serious efforts to control the importation of sheep, cattle, and other animals suffering from contagious or infectious disorders, and from time to time further powers were granted, until their consolidation and perpetuation in the Contagious Diseases (Animals) Act of 1869. The ravages that continued to be committed by certain epizootics gave rise to additional legislative measures, until again codified in the existing Act of 1878, to which amendments have also been added in 1884, 1886, and 1890. So that, as in certain human communicable diseases, the contagious diseases of animals are also subject to compulsory declaration, isolation, and disinfection, with the additional powers of prohibited importation, quarantine, and slaughter.

Animal quarantine, and the precautions to be taken against epizootics, particularly the cattle-plague, were the

subject of an international conference held in Vienna in 1872. The proposals made were numerous, but the essential points may be briefly condensed:—immediate slaughter, with compensation, of all animals attacked by cattle-plague, and of those suspected by reason of exposure to infection; burial of the animals whole, and without utilising any part of the bodies; destruction and disinfection of the contagion wherever it might cling—stables, dung-heaps, harness, pastures, carts, railway waggons, etc.; complete isolation of infected areas, so that no animal could carry infection beyond the area, nor any healthy animal enter; the area might be a farm, a village, a district, or a larger region; the establishment round a large area of a neutral zone, within which the movement and sale of animals susceptible to the disease must be suspended, as well as the transit of animal products and refuse; the compulsory declaration of the occurrence of cattle-plague to an appointed official; the obligation of each State to telegraphically inform—firstly, neighbouring states, and secondly more distant states, of the outbreak of cattle disease within its territory.

These principles are embodied and elaborated in the Contagious Diseases (Animals) Acts and the Orders of the Privy Council (now of the Board of Agriculture) framed under the provisions which are published in the Handbook of the Contagious Diseases of Animals, prepared by the Agricultural Department. Three diseases are specifically and separately dealt with in the Act of 1878—namely, cattle-plague, pleuro-pneumonia, and foot-and-mouth disease; sheep-pox and sheep-scab are also included, and power is given to extend the definition to any disease of animals, and by the Act of 1886 to any four-footed animals. Orders have accordingly been made from time to time also dealing with swine fever, glanders and farcy, anthrax, and rabies, in addition to the previously mentioned diseases. The Board also exercises from time to time the power of totally prohibiting the importation and landing of animals from foreign countries, where contagious disease is known to be prevalent to a dangerous extent.

This is a great protection to the spread of disease in this country; and as the importation of live cattle forms but an infinitesimal fraction of the meat supply, its suspension

can scarcely produce any effect upon the market price, since it only serves to stimulate the importation of dead meat in the place of live animals.

It is necessary to consider briefly the contagious diseases affecting animals.

Cattle-plague, a very fatal aphthous form of eruptive fever, affecting the skin and the alimentary canal, principally attacks the bovine species, and in a lesser degree the ovine. No evidence has been adduced to prove its transmission to man, either aërially or by ingestion, but the infected carcase is invariably condemned and destroyed.

Pleuro-pneumonia is a contagious disease very fatal to cattle, generally killing one in every four attacked. As the name implies, both the lining membrane and the substance of the lung are the seat of the morbid changes, and if the animal succumb early the rest of the carcase generally suffers no apparent alteration. Bovines only suffer from the disease. It is said to have been communicated to children drinking the milk of infected milch-cows, but the flesh is not known to have conveyed the disease to man.

Foot-and-mouth disease is an eruptive febrile disorder, usually running its course in about three weeks. The vesicles dry and form crusts about a fortnight after their appearance, and a week later the crusts fall. Reckoning the initial week, the illness lasts altogether about a month. During this time the milk of cows is infectious, but as its appearance is abnormal and uninviting at the height of the disease, from the presence of stringiness, blood, pus, crusts, and cheesy odour, the risk of using it is in the very early and very late stages. Besides the transmission to man by milk, a German veterinary surgeon is reported to have accidentally communicated the ailment to himself by an infected pocket-handkerchief. The disease attacks more or less all domesticated animals used for human food, including also the horse.

Sheep-pox is a malignant eruptive disease very destructive to the animals, especially when suckling. It is similar to, but not identical with human small-pox. The similar forms of disease attacking the pig, the horse, and the cow are comparatively benign. Horse-grease and cow-pox have been held to be the same disease, and the lymph from both

sources is stated to produce similar vesicles when inoculated upon the human subject. It is from the latter source, the *variola vaccinia*, that vaccination lymph is obtained, and experience shows that calves, utilised for the purpose of reproducing this lymph, recover perfectly from the transient effects of the mild disturbance of health caused by the inoculations.

The mangy condition produced by sheep-scab is due to a zoo-parasite, which is a psoroptic form of scabies that quickly spreads in flocks, and may lead to considerable mortality under unfavourable conditions. The particular ectozoa that give rise to the disease do not obtain any permanent lodgment on man, or other animals.

The epizootic of pigs known as swine-fever, pneumo-enteritis, typhoid, or cholera of the pig, and by other names, is marked externally by patches of congestion and of extravasation of blood into the skin, occasionally by eruptions; and internally by numerous and varied lesions, the most frequent being congestion or inflammation of the lungs, of the intestinal and other glands, and of the serous and mucous membranes of the intestines, terminating in ulceration of the bowel. It is not known to be transmissible to man, but is capable of inoculation into rabbits and mice.

Upon importation, quarantine or slaughter at the wharves set apart for foreign animals at the various ports is applied to cattle, sheep, goats, other ruminants, and swine suffering from cattle-plague, pleuro-pneumonia, foot-and-mouth disease, sheep-pox, sheep-scab, or swine-fever; the carcases, offal, fodder, litter, and excreta are destroyed or disinfected by high temperatures or chemicals; and the infected localities cleansed and disinfected. Similar powers are in force for dealing with imported horses infected with glanders, but from the reports of the veterinary department of the Board of Agriculture it does not appear to have been necessary to exercise them. The orders relating to anthrax and to rabies contain no special provisions in reference to importation.

Glanders or farcy is an intensely contagious febrile disease, which may assume either an acute or chronic form. Whereas in glanders the first and most prominent symptom

is the inflammation of the nasal mucous membrane, accompanied by a discharge terminating in ulceration, and subsequently followed by swelling of the submaxillary and other lymphatic glands, in farcy the most prominent symptoms are inflammation of the lymphatic vessels and glands giving rise to tumours, and an eruption of cutaneous farcy-buds or nodules, both nodules and tumours eventually suppurating, ulcerating, and discharging. The contagium is contained in the secretions and discharges, and it is communicated to everything with which they come into contact, hay, straw, litter, blankets, stall, wall, bin, floor, etc., and public troughs. It is partial to the equine species, but is communicable to other lower animals, and to man in a more or less virulent form. Schilling first recorded its communicability to man in 1821, and since then numerous instances have occurred, the more recent having been confirmed by the discovery of the characteristic bacillus both in the horse and in man. The ass is particularly susceptible, although the ox is insusceptible to the disease. Several thousand horses are attacked in the course of each year by the disease in the British Isles. By careful examination, isolation, and slaughter, the disease might be reduced to small proportions, if not extirpated altogether. Inspection of imported horses and exclusion of those from infected areas would be required to prevent its re-appearance. In view of the increasing use of horse-flesh for human food in Europe, more careful supervision of this disease is becoming urgently necessary.

Under treatment the disease may be alleviated and remain quiescent, ready to assume an aggravated form under adverse conditions. The infected animal may in the interim infect others, the virus being readily conveyed by fomites and intermediaries, and adhering persistently to the stable and utensils. Neglect to immediately slaughter infected, and to strictly isolate suspected animals leads only to a dangerous and costly extension of the disease.

Anthrax, also known as splenic fever, wool-sorters' disease, malignant pustule, and charbon, is a disease of horses, cattle, and sheep, communicable to man. Externally, a carbuncle usually develops at the point of inoculation, and internally congestions and exudations take place, especially

in the spleen. The disease is very fatal, and occurs in all parts of the world, but with unequal severity. It was in 1849 that Pollender discovered the *Bacillus anthracis*, the cause of the disease, and since that time this microphyte has probably had more attention paid to it than any other, and its life-history has been fully traced. It is readily communicated through a break in the surface or through inoculation, either by means of animals or their products, and by infected fomites or localities, one of its designations pointing to a common source of the disease—namely, wool-sorting.

Sometimes the disease assumes a broncho-pulmonary form from the irritating, infected dust inhaled, and frequently proves fatal within a week. The prophylactic measures necessary are perfect ventilation of the work-rooms, burning the dust collected in the ventilators, disinfection and cleansing of the hands of the workers, the use of special clothes, to be changed on coming and leaving, strict abstention from eating or drinking in the work-place, and especially disinfection of the infected wool by superheated steam before handling.

Closely allied to anthrax is a disease known as black-quarter, or symptomatic anthrax, which is accompanied by irregular swellings, turning ashy or black in colour. It chiefly attacks young cattle and lambs, and often spreads as a fatal epizootic, causing death within two days or less of invasion. The characteristic bacilli have been found in most parts of the body, but especially in the tissues and fluids of the tumours. Calves, sheep, goats, rabbits, and guinea-pigs are susceptible to the disease by inoculation; horses and asses less so; and swine, dogs, cats, and fowls are insusceptible; but it is not known whether man is susceptible, no instance of human infection having been recorded.

Rabies, or hydrophobia, is transmissible by inoculation to all domestic animals and man, through the medium of the saliva, blood, and nervous tissues, but mainly prevails in the dog. The extreme fatality of the disease renders it desirable to sacrifice much in order to extirpate it. It is communicated by the bite, and a rabid dog snaps at everything, real or imaginary. Hence, although when rabies is

recognised the animal should always be killed, generally it will have already widely communicated the disease before an end is put to its career.

Experience, both on the Continent and in England, has proved that the muzzle is an effectual preventive of the spread of hydrophobia, within the area of its enforcement. The Registrar-General, in his Fifty-third Annual Report, notes that the deaths from hydrophobia, which averaged 24 annually in 1887-8-9, and were 30 in the last of the triennium, fell to 8 in 1890. This decrease was coincident with a decline in canine rabies, the returns of which to the Board of Agriculture averaged 230 annually during the same triennium, were 312 in the last of the three years, and fell to 129 in 1890. The decline is coincident with the application of the Muzzling Order, from 1st January 1890, to the counties in which rabies was prevalent—namely, those of which London and Lancashire form the centres. In these two areas rabies mostly prevails, and here are also to be found the two largest cities and ports in England.

It has accordingly been proposed to apply quarantine, in order to exclude the importation of rabies by dogs. A period of observation-detention before admission would require the provision of kennels and attendants. As to exclusion by prohibition, many breeds of dogs being small animals, it is less possible to discover and control their movements than in the case of cattle, or even of sheep and pigs. Compulsory muzzling is the only practicable check on a large scale to the spread of hydrophobia, and the only debatable point is the limit of the area over which the compulsory muzzling requires to be enforced in order to be effectual. Doubtless from time to time, in spite of all precautions, rabid animals in the incubating or defervescing stage will gain access to an area free from the disease.

At present, when an area is declared under a compulsory Muzzling Order, the area is not bordered by a neutral zone, and hence muzzled and unmuzzled dogs, either on the public way or on private and adjoining premises, are not rigidly separated. A muzzle is not a very perfect form of instrument even at the best, and the close proximity of muzzled and unmuzzled dogs tends to render the defence imperfect.

For this and for other reasons, in addition to muzzling, the prohibition of the movement of dogs from a scheduled to a free area, and *vice versâ*, is required to complete the protection.

The less onerous measure of collar registration, for the purpose of securing such cases of rabies as occur amongst stray dogs, if effectually carried out, may prove useful, but is on its trial. That ownerless dogs suffer heavily from rabies appears from the Report of the Board of Agriculture, the rabid dogs returned as stray in each of the years 1888, 1889, and 1890 being respectively 40, 38, and 52 per cent. of the totals. The vigilance and control of owners over their dogs must exercise a considerable effect in diminishing the spread of the disease; and whereas a Muzzling Order would appear to increase this control, the wearing of a registered collar may possibly tend to relax it by inclining owners to trust to the collar itself as a prophylactic.

As in certain infectious diseases of man, so also compulsory notification is required by law when an animal is affected with either cattle-plague, pleuro-pneumonia, foot-and-mouth disease, sheep-pox, sheep-scab, swine-fever, glanders or farcy, anthrax, or rabies.

Seeing that the public health is more or less liable to be affected by certain of the contagious diseases of animals, as well as by the quality of their flesh, and that the places in which they are kept or slaughtered, or in which their products are worked upon or sold, and that the nuisances they may give rise to, are subject to the supervision of sanitary authorities, it appears somewhat anomalous that notice of outbreaks of contagious diseases amongst animals should be kept from their cognisance. By the Acts it is made compulsory that the notice of contagious disease should be given to a police constable, whose duties are otherwise remote from the prevention of disease. The country is studded thickly with sanitary inspectors, and it is to be regretted that their services are not utilised for this purpose. The sanitary inspector would seem an appropriate addition to the police constable for many of the purposes of the Acts, without in any way disturbing the responsibilities of the county inspectors, or of the inspectors of the Board of Agriculture.

It is also compulsory upon the owner to isolate an animal

suffering from either of the before-mentioned diseases scheduled for compulsory notification, and no animal can be removed from the place of isolation alive without licence. This is then known as an *infected place*, and upon the declaration of the inspector of the local authority the space lying within a distance of half a mile from the infected place or centre becomes an *infected circle*. The Board of Agriculture decides and directs the extent of the area to be declared an *infected area*, into, within, and out of which no movement of animals, or of objects in contact with animals, may take place without the consent and except under the regulations of the Board. The isolation of an infected circle or of an area is maintained by a police cordon.

The Board issues orders for directing what infected or suspected animals shall be compulsorily slaughtered, and compensation is paid to the owner in cases of cattle-plague, pleuro-pneumonia, foot-and-mouth disease, sheep-pox, and swine-fever. Destruction of the carcase in its skin, after slashing it, either by burial in six feet of earth with quick-lime, or by subjection to strong chemical agents, or to a high temperature, is compulsory after an animal has died or has been slaughtered whilst suffering from pleuro-pneumonia, foot-and-mouth disease, sheep-pox, sheep-scab, glanders or farcy, swine-fever, anthrax, or rabies; and the destruction must take place in a specified manner, and under inspection. All fodder, litter, dung, and other things that have been used about, or in contact with animals infected with any of the diseases must also be forthwith disinfected, burnt, or destroyed. Every fixed or movable construction, such as lairs, stalls, pens, vans, trucks, must also be cleansed and disinfected in every part after harbouring infected animals; scraping, scouring, and lime-washing being the usual means employed.

Certain other diseases more or less assumed to be communicable to man from living animals, but not recognised in the Contagious Diseases (Animals) Acts, must also be mentioned—namely, actinomycosis, erysipelas, influenza, tuberculosis, diphtheria, scarlatina.

Actinomycosis is most frequently observed in the tongue and in the jaws of cattle, especially oxen; but it also attacks the lungs. It is not common in man, but cases occur from

time to time. The disease is characterised by inflammation and swelling at the affected spots, and the formation of nodules and abscesses due to the irritation caused by a microphytic organism (*Actinomyces*). Although for a number of years this disease has been known, it is only recently that its true nature has been understood. The microbe gains admission to the tissues naturally through a break of the surface, especially about the mouth, when it is probably introduced by the food, and artificially through inoculation.

Erysipelas is met with in all the domesticated animals, and it is probable that the *Micrococcus erysipelatosus* finds a suitable nidus in all wounds, both of man and animals, whether it be derived from a saprophytic or a pathogenic source.

Considerable interest attaches to the origin of influenza, a disease to which the horse is specially susceptible. There is much uncertainty in its definition, quite a number of types of disease being classed in the same category. There is a catarrhal form, a bilious form, and what is known as "pink eye," also an enteric, and a cerebro-spinal form. Instances of communication of the disease to cattle are rare. Whether or not it is transmitted to man is vigorously contended from opposite points of view. It is not readily conveyed to man, since attendants on horses do not suffer exceptionally from influenza; but the curious coincidence of epizootics of influenza frequently immediately preceding epidemics of the disease requires something more than mere denial to destroy the strong suspicion that either a direct or indirect connection exists between the outbreaks in horses and man. It has been frequently observed that a form of epidemic catarrh may concurrently attack households and domestic pets, as dogs, cats, and birds; and Dr. Bruce Low has collected a number of instances in which human sufferers have been convinced that they contracted the disease from horses.[1] The contagium of influenza is capable of rapid centrifugal infection from man to man; but it is probable that, previous to acquiring this ready diffusion, it undergoes a process of adaptation leading to parasitic existence in the human system. There is ground for this

[1] See Dr. Parsons' *Report to the Local Government Board on the Influenza Epidemic*, 1890.

assumption in the apparent origin of some epidemics under certain unhealthy conditions, and the variation in the virulence of others due to changes of environment; and especially in the experimental instances of increased virulence, that is increased adaptation, after passing successively through a number of individuals of the same or of different species. Hence, although the transmission of influenza from horse to man may be of rare occurrence and difficult to trace, it cannot be held not to occur, nor can it be denied as a possible origin of a pandemic, either directly or indirectly.

It is beyond dispute that tuberculosis may be conveyed to man and animals by the ingestion of tuberculous milk, meat, and other infected food; and also that the inhalation of tuberculous matter in a pulverulent form, dry or moist, may give rise to the disease. The tubercle bacillus being resistant to adverse influences, retaining its vitality for a considerable period even external to the body, and all animals being more or less prone to its attacks, the extent of its prevalence amongst animals must necessarily become wider if not limited by preventive measures. Such measures become the more necessary in a disease that may be spread both by the mouth and by the food products, milk and flesh. The measures that would appear to be indicated are the careful isolation of suspected animals, the slaughter of those affected, and the disinfection or destruction of infected flesh, fodder, litter, etc., as in other contagious diseases. The disease predominates amongst milch-cows closely housed in sheds, and especially town cow-sheds, and infects the milk produced. Many ways exist for the communication of the disease to animals from man, but one in particular deserves mention. It is no uncommon thing for cattle to gain access to and drink the water used in household washing, but Guinard[1] states that some of the French peasantry regularly give the washing-water to the cattle to drink, and records observing that the handkerchiefs of a phthisical patient, saturated with tubercular sputum, were washed in water so used, doubtless leading to the transmission of the disease to the animals. As polluted drinking water is the means of the introduction of many diseases to

[1] *Lyons Méd.*, 1891.

man, there is some reason for assuming that similar results may follow its consumption by animals. In this light the water to which access is obtained by milch-cows must exercise an important influence upon their health, and the purity of the milk they supply.

Poultry and other food birds, as pigeons and pheasants, are attacked to an enormous extent by the disease, and much of what was regarded formerly as diphtheria is now known to be tuberculosis. Birds, nevertheless, are subject to a form of diphtheria allied to the same disease in man, but whether they are also subject to infectious pneumonia or to influenza, we have no certain knowledge. Recently some hundreds of parrots were brought from Brazil to Paris, and let loose in the empty room of a dwelling-house. An epidemic broke out amongst them, destroying all but a few. Meanwhile certain of them were sold. The purchaser of one of the birds, the friend to whom it was given, and her sister were attacked with what appeared to be a severe infectious pneumonia. The partner of the importer also fell ill and recovered. His brother, who lived with him, died; his brother-in-law also had a serious attack. The man and his wife, who housed the birds, became moribund, and another elderly woman fell seriously ill. The doctor who treated the patients fell sick with pneumonia. A gentleman who bought two parrots also fell very ill, and a lady, to whom he gave one, died, as well as the *concierge* of her house. Other persons fell seriously ill at Vaugirard, Clamart, and at Charenton. The importer visited a wine-shop, the keeper of the wine-shop and his niece became infected, fell ill, and died some days after of infectious pneumonia. A night-nurse, attending on a patient suffering from the disease, was also attacked. Professor Peter came to the conclusion that the disease was transmitted both from the birds to the patients, and from patient to patient, and considered it a sort of typhus. Professor Cornil came to the conclusion that it was a new disease. M. Dujardin-Beaumetz found that animals brought into contact with the parrots died, but there was no proof of infectious pneumonia amongst them. He considered the disease a pneumonic form of influenza, the germs probably conveyed in the plumage of the birds.

But this leaves unexplained the cause of the mortality amongst the parrots.[1]

Of all the ingesta by which disease may be conveyed, with the exception of water polluted with cholera and typhoid contagia, milk is the most fertile medium for the transmission of disease. This is due to the fact that milk is an organic fluid derived from an animal in the puerperal condition, a highly nutritive medium for the growth of organisms gaining access to it, liable to fermentative and putrefactive changes, and rapidly absorbing gaseous or diffusive substances in its proximity.

Since Mr. Ernest Hart collected and recorded[2] fifty epidemics of typhoid fever, fifteen of scarlet fever, and seven of diphtheria, due to infected milk, others have from time to time occurred. Cholera must be added, and, according to the observations of Dr. Tompkins of Leicester, also summer diarrhœa, to the list of diseases conveyable by milk. But besides these diseases that may be derived from contamination of the milk by infected individuals, or by gases and vapours, or by water used for cleansing or dilution, certain other diseases may be transmitted without human or external agency, the milch-cows being themselves the subjects of disease. Foot-and-mouth disease may be so communicated, probably also pleuro-pneumonia, certainly tuberculosis; there is strong presumption for adding scarlatina and diphtheria, and it has been suggested that even typhoid may possibly be so transmitted.

That foot-and-mouth disease has been communicated from cattle to human beings through milk was reported by Mr. Bird Vincent at East Dereham, in Norfolk, and by Dr. Robinson at Dover in 1884. Dr. Nevitski also traced a group of cases to cows suffering from the disease whose milk had been drunk. The record of the epidemic observed by Dr. Robinson is explicit. During the last week in January 1884, the milk of some milch-cows suffering from foot-and-mouth disease at a farm in the country was sent into Dover, and supplied to the customers of a dairyman; during the following week or ten days a peculiar affection of the throat and mouth attacked some two hundred

[1] *Lancet* and *Brit. Med. Journ.*, April, 1892.
[2] *Trans. Inter. Med. Congress*, 1881.

customers of that particular dairyman, and the epidemic was confined to those consumers. The symptoms consisted of sore throats, fever, enlargement of the glands of the neck, and in some cases a vesicular eruption of the throat, of the lips, or of other parts of the body. A second simultaneous outbreak occurred amongst the customers of another dairyman, supplied from the same farm. Further corroboration was afforded by the fact that a dog suffered from a similar affection of the mouth and leg after being fed upon the milk.

With regard to the transmission of tuberculosis by milch-cows, it has been held that it is only carried by the milk when the mammary glands themselves are affected by the disease, but such a limitation must be accepted with caution, as tubercle bacilli travel with considerable facility in the lymphatic and glandular system. The incidence of abdominal tubercular disease almost exclusively upon children of milk-drinking ages is held to be largely attributable to infected cow's milk. It is scarcely possible to distinguish the initial stages of tubercular disease of the mammary glands, neither can air-borne infection be excluded as a means of contaminating the milk in closely confined town cow-sheds, where tuberculosis mostly prevails, and by which means it is probably transmitted from cow to cow. Hirchberger's and Bollinger's experiments, at Munich in 1890, by the inoculation of animals with milk from tuberculous cows, resulted in transferring infection in 55 per cent. of the cases, and the conclusion was drawn that the more general the tubercular affection the greater the danger, but that the transmission of infection occurs also in localised tuberculosis of a mild form.

The investigations of Power and Klein and others would lead to a presumption that milch-cows may contract both diphtheria and scarlatina in a form not easily recognised, and that the consumption of the milk of animals thus affected may lead to the development of these diseases in man. The investigations of Mr. Power into an outbreak of scarlet fever in St. Giles and St. Pancras in 1882[1] first gave strength to the suspicion that scarlet fever might possibly originate in the cow, apart from human infection of the

[1] *Twelfth Report of Medical Officer of the Local Government Board.*

milk, and, since the Marylebone and Hendon outbreak in 1885, the successive annual reports of the Medical Officer of the Local Government Board have not failed to contain additional researches and observations, tending to lend support to this contention. Dr. Klein has isolated a similar streptococcus both from the diseased organs of the cow and of man, and inoculation experiments have produced a disease in the cow similar to human scarlatina. More recently by actual inoculations of scarlatinal matter from the human subject he has reproduced in the cow the same disease. But these results have not yet been confirmed by other experimentalists, since no attempt has ever been made to test them. More recently still Dr. Klein has succeeded in inoculating cows with the diphtheria bacillus, in obtaining the bacillus again from the milk of the cows, and in communicating the disease by inoculation from cow to cow, with the repeated result of producing circular ulcers on the udder and teats of the cows. The outbreaks of human diphtheria, recorded by Dr. Philpot at Croydon in November 1890, and by Dr. Turner at Bishop's Stortford in April 1891, coincident with the supply of milk from cows suffering from similar ulcerations of the udder and teats, tend to confirm the conclusions of Klein. And further confirmation is lent by the outbreak of diphtheria, with the growth of croupous membrane, in the cats at the Brown Institution that had drunk the milk from the cows infected by inoculation for experimental purposes.

The failure to trace the source, and the coincidence of a diseased condition of cows supplying the milk, has also led to the inference that certain epidemics of typhoid spread by milk may have been transmitted by cows. An outbreak of disease amongst cows at a dairy near Glasgow, causing diarrhœa amongst the consumers of the milk, was considered by Dr. Russell to be caused by the sewage-polluted water drunk by the cows.

When acute infectious disease is spread in epidemic proportions through the medium of milk, it usually attracts attention by the suddenness of the outbreak, the immediate extent of its diffusion through the district, and the number of simultaneous attacks in each house or household. On inquiry it will be found that a large proportion of the

households attacked have been either supplied by the same dairy or milkman, or, if by several, further inquiry will elicit the fact that they have been wholly or partly supplied from a common source, a large dealer or a farmstead. The incidence of the disease in each household will vary in proportion to the amount of milk consumed, and to the treatment it has undergone, whether consumed pure or mixed with tea or coffee, and whether after boiling or in the crude state.

So far as disease in the cow is concerned, the precautions that appear necessary are—that any disease of the udder, including garget, weed, other forms of mammitis, and eruptions should disqualify the milk for the use of food; that a milch-cow suffering from any disease, or disturbance of health beyond the normal puerperal condition, should be immediately isolated, and neither the milk nor the flesh be used until pronounced free by veterinary opinion; if slaughter be necessary, the owner should be compensated. In short, the production of milk requires to be as much under State control as its storage and distribution now are under the Cow-sheds, Dairies, and Milk-shops Order of the Privy Council (now transferred to the Local Government Board), and the Regulations of Local Authorities made thereunder. The present provision made for the inspection of cattle in dairies is insufficient to meet the case, although the existing provisions and regulations for controlling the sanitation of dairies and cow-sheds, and for preventing the contamination of milk by foul air, polluted water, dirty utensils, or infected persons, are in most cases excellent if carried out. One source of contamination can only be avoided by personal cleanliness; the hands of milkers and the udders and teats of cows should be washed before milking. A fertile source of contamination, not readily recognised on account of the limited extent to which it may prevail in each case, is the number of premises, especially in large towns, where milk is retailed in a small quantity, together with a thousand and one miscellaneous articles. The sale of milk requires to be restricted to premises selling only foods, and possibly limited to dairy foods, and power should be given to local authorities to refuse registration for the sale of milk unless the premises are in a satisfactory sanitary condition, and proper

provision is made for preventing contamination and for cleansing. Furthermore, local authorities should possess control over milk in transit for the purpose of preventing its contamination.

The consumer has it within his own power to provide that his milk when received shall be stored in a clean vessel in an unsuspected atmosphere, and shall be heated to boiling-point before consumption; although if milk contains the spores of tubercle, the boiling must be maintained some time to kill them effectually (Pasteur).

With regard to meat, most of the communicable diseases from which animals suffer are not recognisable in the early stages by superficial inspection of the muscular tissues only, and many are not then detectable by the naked eye even in the internal organs. Various stainings, serosities, abscesses, and other changes may be noticeable in later stages in all diseases in which acute inflammatory action, whether general or local, has taken place. It is a question of considerable difficulty to decide whether whole or part of a carcase should be prohibited as food for man, and in what diseases prohibition should apply. It may be said that any organs and carcase that have undergone general change should be wholly destroyed, the septic products apart from other disease requiring this. But, assuming that no change has taken place in the appearance of the carcase and organs of an animal that has suffered from a communicable form of disease, it must depend upon many considerations whether its destruction is wholly or partly advisable.

The legislature has decreed the total destruction of the carcases of animals suffering from, or suspected of suffering from, pleuro-pneumonia, foot-and-mouth disease, sheep-pox, sheep-scab, glanders or farcy, swine-fever, anthrax, and rabies, and if rigidly enforced, it should not be possible for meat infected with any of these diseases to come upon the market, except as imported meat. The escape of imported meat shows that the institution of public abattoirs is not a *complete* panacea for the distribution of diseased meat. Besides the diseases above-mentioned, black-quarter or symptomatic anthrax, it may be added, although this disease has not been recorded as transmissible to man, renders meat unfit for human food. In actinomycosis it has been

held that it is sufficient to remove the diseased parts or organs, but this must provide a very insecure protection, since the spores may travel to distances from the seat of origin. The same treatment has been held to suffice in regard to tuberculosis.

The inspection of meat for tuberculosis after it has been trimmed and prepared for retail sale fails to readily detect its condition. Even inspection at the time of slaughtering requires an expert to examine the carcases, and this can only be properly carried out in centralised abattoirs. But the communicable character of tuberculosis requires measures to be taken during life, especially amongst milch-cows packed together in sheds or byres in a cubic space for each animal of 400 cubic feet. Whether tuberculosis in milch-cows should not be declared or notified is a matter for serious consideration. But that suspected animals, both in the interest of the owner and of consumers, should be removed from a herd, and not be used for the supply of food without the consent of an expert after a proper examination, can scarcely be denied. In fact it is a serious question whether isolation in a modified form should not be applied to tuberculosis both in animals and man, and be followed by disinfection.

To return to tuberculous carcases, the question at the present moment at issue is whether only part or the whole of the carcase of an animal that has obviously suffered from tuberculosis of certain parts or organs should be destroyed as unfit for food. It is well established that tubercle bacilli may travel in the lymphatic and blood-vessels, and infect the general system, although they can only be discovered after a very minute and tedious examination by complicated processes in a special laboratory, and are not observable to the most careful naked eye inspection. Unless it can be positively said that the infective organisms are confined to the part affected, the excision of only that part or organ must afford but an insecure protection.

It is established that, both by inoculation and feeding, the lower animals can be infected with tubercle derived from the human subject, that in a similar manner bovine tuberculosis may be transmitted to other animals, and, by analogy it is assumed, to the human subject.

The juice of muscles apparently free from tubercles is capable of infecting animals when injected. Kastner thus infected 4 out of 16 guinea-pigs; in Steinheil's experiments 15 out of 18 died of tuberculosis.[1] Toussaint and Bowley succeeded also in producing similar results. Professor Brown, director of the Veterinary Department of the Board of Agriculture, in the Annual Report for 1890, describes a number of experiments, the results of which were that of 13 animals fed upon muscle, etc., from undoubted cases of tuberculosis, 10, or nearly 77 per cent., became affected with tuberculosis. The degree of the infectivity of the meat of tuberculous animals, in the absence of obvious tubercles, is at the present moment the subject of inquiry by a Royal Commission, and experiments are now being conducted for the purpose of deciding this question of pathogenesis.

It has been advanced that the cooking of meat destroys the chances of transmitting tuberculosis, but the ordinary modes of cooking do not destroy the bacillus, and have absolutely no effect upon the spores, which are one of the chief means of propagating the disease. Blood coagulates at 160° F., and it is well known that in the interior of a joint the blood is seldom found coagulated, and in underdone meat runs out upon cutting, but the spores of the tubercle bacillus are even more resistant to heat than anthrax spores,[2] and the latter require a temperature of boiling water to destroy them.

At the second Congress for the study of tuberculosis in man and animals, held in Paris at the end of July 1891, the following important resolutions were passed:—"It is necessary that all Governments should decree the most efficacious prophylactic measures for preventing the extension of bovine tuberculosis. It is urgently necessary to establish a special inspection of meat in all towns, without exception, provided with a public abattoir. It is equally necessary to suppress all private slaughter-houses in towns containing more than 5000 inhabitants, and to replace them, as soon as possible, by public abattoirs; effectual inspection is impossible without this measure." The Congress reaffirmed the opinion of the Congress of 1888, that,

[1] *Münich Med. Wochenschr.*, 1889.

[2] Flügge, *Micro-organisms* (Cheyne's translation), p. 664.

whatever the degree of gravity of the specific lesions found, the flesh of tuberculous animals should be seized and destroyed, and the owner compensated. The Congress also reaffirmed the necessity for the special inspection of milch-cows, in order to secure that animals producing milk for consumption are not suffering from any contagious diseases (including tuberculosis) capable of being communicated to man. It was also recommended that places in which tuberculous animals or persons have lived or died be disinfected, and that the sputa should be disinfected in all expectorating diseases. In addition, Professor Whalley is of opinion that all meat coming from outside the boundaries of a town should pass through the public abattoir for inspection. The greater the restrictions upon the importation and movement of live animals, for the purpose of discovering and excluding disease, the larger the proportion of animal food that is placed upon the market dead, and consequently the more the necessity increases for extended and thorough inspection of dead meat supplies.

Condemned meat, when not absolutely destroyed by fire or by burial, after being slashed and treated with chemicals, is melted down to extract the fat, or manipulated for other purposes.

In Berlin experiments have been conducted by Hertwig and Duncker[1] at the central slaughter-houses for the purpose of disinfecting meat. Boiling, baking, and roasting, as ordinarily practised, commonly fail to destroy infective matter contained in meat, such as tubercle, on account of insufficient penetrative power. In the Berlin experiments the cooking was done by steam in a Rohrbeck disinfector, and by means of special cooling and condensing apparatus the pressure of the steam was made to vary, so that the penetration and cooking were more rapid and complete. The results were verified by inoculation experiments. The cooked meat, which included also internal organs, was juicy and of more pleasant odour and flavour than boiled meat. Disinfection thus applied may obviate the necessity for the absolute destruction of certain flesh foods at central slaughter-houses, and permit of its consumption without injury by animals, if not by man.

[1] *Zeitschrf. für Fleisch- u. Milch-Hyg.*, Jahrg. II.

This chapter cannot be concluded without reference to the zoo-parasitic diseases of meat, the most important of which are trichinosis of the pig, measles of the pig, and measles of the ox. The *Trichina spiralis*, the cause of trichinosis, is the most dangerous of these, both on account of the serious results to man when ingested, and because its minute size renders its discovery impossible by the naked eye. Subjecting thin sections or teased fibres of the flesh of a diseased pig, treated with acetic or weak hydrochloric acid, to microscopical examination, with lenses of comparatively low power, discloses a fusiform or lemon-shaped capsule, within which a minute hair-like worm is coiled, or a very strong hand lens will in pronounced cases show the presence of the cysts in the fresh-cut muscular surface. Infected pork, when discovered, is invariably condemned and destroyed, for although the disease is most commonly communicated by pork or ham when eaten raw, as in Germany, cooking cannot be depended upon for destroying the trichinæ in the interior of joints.

Measly pork is due to the presence of the hydatid *Cysticercus cellulosæ*, which, when ingested, develops into the *Tænia solium* or tape-worm in man. The cysts or bladders are readily visible to the naked eye, varying in size from a millet seed to a bean, and their presence warrants the condemnation of the meat in all cases. Although they are readily killed by cooking if the meat be in thin slices, they may escape in the interior of joints, and salting and other modes of preservation do not destroy their vitality unless very thorough and prolonged.

Measly beef is due to the presence of the hydatid *Cysticercus bovis*, which, when ingested, develops into the *Tænia mediocanellata* in man. It is not commonly met with in this country, but when found the appearances of the meat are similar to those of measly pork, and the meat must be equally condemned.

There is also a form of bladder-worm that infests man, derived from the *Tænia echinococcus* of the dog. This *Tænia* is the cause of the hydatid *Echinococcus veterinorum*, frequently found in organs of cattle, by which intermediate hosts it is perpetuated. Its occurrence in cattle always calls for the condemnation of the organs, both on account of its repul-

siveness and to prevent its perpetuation through dogs, from which source man may be infected with hydatids.

The hydatid *Cœnurus cerebralis*, the cause of the staggers in sheep, is also found occasionally in man, and is derived from the *Tænia cœnurus*, also of the dog. In order to prevent its perpetuation it should also be destroyed.

Many other zoo-parasites are met with in animals, but as they are not transmissible to man, they are of less import to the public health, except when they cause nutritive or septic changes in meat.

There can be little doubt that many foods eaten in the raw state may also become contaminated, and convey both macro- and micro- parasites, animal and vegetable, to the human economy. It has been suggested that oysters may convey typhoid from beds in proximity to sewage outfalls; the risk would appear somewhat remote. The predominance of entozoal diseases in rural over urban districts has been attributed to the greater facilities for eating fresh raw vegetable food. There is no doubt that liquid manure is occasionally used for the purpose of watering lettuces, radishes, mustard and cress, endives, celery, etc., and that water-cress may flourish in sewage effluents. Plentiful washing with running water, or cooking, will render such food innocuous, and hence personal habits are of greater influence here than other circumstances.

Upon the subject of the prevention of entozoal diseases in man, a terse and pithy paper was read by Dr. Prospero Sonsino, of Pisa, at the International Congress of Hygiene in London, and the observations bore directly upon prophylaxis and sanitation. The entozoal diseases are more readily prevented than the entophytal, provided the manner of introduction of each entozoon is known, for two principal reasons. Firstly, whereas the microphytes may multiply indefinitely, generation after generation, within the body of the host, the entozoa only produce an effect in direct proportion to the number of entozoa introduced. Even in trichinosis the effect is limited to the comparatively few larvæ that may be produced by each individual trichina, and the multiplication proceeds no further. Secondly, whereas many microphytes may gain access to the system of the host, borne by the air or by direct inoculation,

entozoa mainly enter by ingestion, so that, care being exercised over the kind and condition of the substances swallowed, and entozoa possessing no alternative mode of entrance, they are more certainly excluded. The prevention of entozoal diseases is therefore mostly dependent upon personal cleanliness in living, eating, drinking, and washing. Hence entozoal diseases are most common among the less civilised nations, amongst whom habits of personal cleanliness and care in the choice and preparation of foods and drinks are least cultivated. On the other hand, the phenomenon of future immunity produced by an attack of certain of the microphytic diseases is not obtained after harbouring entozoa, and the condition of previous or present health of the individual does not appear to produce any effect upon their vitality and parasitic capacity, if they gain access at the proper period of their development.

The filtration of drinking-water suffices to remove the entozoa, on account of the relatively large size of the eggs and larvæ. The neglect of this precaution in tropical countries accounts for the greater liability of the natives than of the white population to harbour *Bilharzia*, *Filaria*, *Dracunculus*, and *Rhabdonema*. Boiling the water is even more efficacious, and drinking only water derived from pure springs is a still greater safeguard, since not only are entozoa avoided, but also microphytic organisms.

The thorough cooking of meat, fish, and vegetables intended for food, so that the interior reaches a temperature of at least 140° F., is necessary to kill the ovoid or larval forms of *Trichina*, *Tænia solium* and *sarginata*, *Bothriocephalus latus*, *Ascaris lumbricoides* and *mystax*, *Distomum lanceolatum*, and *Fasciola hepatica*, etc. Depraved tastes, and the consumption of special kinds of foods, raw or insufficiently cooked, in certain countries are the cause of the prevalence of these and many other entozoa, of which the life-histories are less known.

Personal cleanliness, especially of the hands and nails when about to handle food or to partake of it, is also essential. The prevalence of *Anchilostoma* amongst the canal diggers in Egypt is due to the handling of mud containing the larvæ of this entozoon. Thread-worms and tapeworms that may escape from the body, if adhering to the

hands, may re-infect the host by being again swallowed. The handling of domestic animals may also lead to acquiring entozoa, by the adhesion of the eggs ; from dogs the *Tænia echinococcus* and the *Pentastomum tæniodes* may be thus derived.

Epizoa, as mosquitoes, bugs, fleas, etc., should be kept away from the body, as part of the life-cycle of some parasites is passed in these insects, notably several of the *Filariæ*, and it is suspected that they transfer other diseases. For the same reasons other insects of various kinds, including flies, should be carefully kept from settling upon food.

PART IV.

THE URBAN DWELLING.

CHAPTER I.

URBAN CONDITIONS.

In its earliest form, apart from the devices for defence against savage animals and men, the dwelling was merely a shelter from the sun and the rain from above, and the hot or cold winds from exposed sides, natural clefts and cavities being first utilised. As a rudimentary idea of construction developed, artificial structures replaced natural cavities, assuming first the form of temporary and movable tents and wigwams, and becoming more or less permanent and fixed according to the degree of civilisation, the requirements of climate, and the use of fire. As through the ages the art of construction progressed it expended itself mainly upon religious, state, and military buildings, the masses of the people continuing to dwell in hovels. The descriptions in historical records of the dwellings of the people of Europe in the Middle Ages, and even to later periods, bear witness to their ill-constructed and unwholesome condition.

The diffusion of prosperity, and the increase of knowledge and skill have gradually led towards the erection of dwellings with the object of enclosing a modified climate and atmosphere, permitting of their enjoyment whilst excluding external and eliminating internal injurious influences, extremes of temperature, rainfall and dampness, darkness and foulness. As the dwelling-house increases in size from the single or double-roomed cottage to the house

of four, eight, ten or more rooms, or further to the lofty building containing many dwellings, the conditions become more and more complicated, whilst the closer and closer aggregation of houses in the growth of towns, adds enormously to the difficulties of securing the absolute necessaries of life in sufficient quantity and of sufficient purity, namely, light, air, and water. Thus matters formerly regarded as private have now become subjects of public concern.

In the strictly rural dwelling the protection of health is a less complicated task than in urban communities, where the supply of necessaries and the removal of waste introduce problems of vast dimensions, especially in reference to water-supply, sewerage, and scavenging, and where the means for the introduction of disease and the deterioration of health are multiplied many-fold.

From without, communicable disease may be introduced into the dwelling by suffering or convalescent individuals; by fomites retaining infection; by food, especially milk, conveying typhoid, scarlatina, diphtheria, and tuberculosis; by water carrying typhoid and cholera; by drain and sewer vapours wafting the infective particles of typhoid, and of diseases affecting the throat; and by the air of the subsoil, of the soil, and of surface refuse. When infectious disease has obtained access it spreads with a certainty, rapidity, and virulence, in proportion to the proximity of the occupants of the house, the dwelling, and the room. This is notably the case with typhus fever. Hence it is not only necessary to exclude disease, but to minimise its effects by the avoidance of overcrowding, the cultivation of cleanliness, and the promotion of measures inimical to disease generally. These measures cannot halt at the prevention of certain diseases, for it is difficult, if not impossible, to trace many diseases to particular causes connected with the habitation, except in glaring instances, because the low vitality produced by conditions inimical to the maintenance of health is itself a predisposing cause to most diseases, and especially to the communicable class, that are always at hand to invade the sickly. The efforts of public health administration are therefore not limited merely to the prevention of death or even of disease, but embrace the promotion of health.

Observation and experiment having more or less determined many of the conditions necessary for the maintenance of health, when those conditions have been fixed their infringement must be held to lead to the deterioration of health, and to the ultimate invasion by disease. It then becomes the duty of the State and of local authorities to concert the public measures requisite in order to obtain those conditions, and to enforce them by statute and municipal law for the protection of the community. These measures are embraced as a whole in the modern term SANITATION.

Sanitation is a subject of immense proportions, but attention will be confined, within the space at disposal, to urban sanitation, more particularly to conditions immediately affecting dwellings, and especially the dwellings of the poor. The great watershed questions connected with the sources of water, and the ultimate disposal of sewage and refuse, cannot be embraced in a short chapter or two. This is the case also with the large urban questions connected with the supply of water and the removal of liquid and solid refuse. Also the questions of thoroughfares, and works connected with them above and below ground, levelling, paving, scavenging, and the laying of pipes, conduits, and tubes for gas, water, sewage, and various forms of power, electric, steam, hydraulic, and pneumatic. Public baths and wash-houses, public mortuaries, public parks and gardens, and other public conveniences, although necessitated by the closer aggregation of dwellings in towns, must also be passed over in order that the more immediate points connected with the obstruction of light and air, and the pollution of air and water in and about dwellings, may be more fully considered in reference to water-service, house-drainage, domestic refuse removal, but above all to the structural proportions, arrangements, and conditions of humbler dwellings as affecting health.

The growth of a town and the consequent risk of pollution of the surface and subsoil brings with it the abolition of surface wells, and as the town extends its area, water is no longer obtained by the pail from the well on the premises, but is supplied by the pipe from the spring beyond the town, and later, at high pressure, from the

reservoir, which in its turn is supplied from some more distant source, far from polluting agencies. Thus the quality and quantity of water-supply presents increasing difficulties recurring at successive periods of growth. With the greater facility of supply the quantity consumed increases, so that thirty gallons per head per diem has come to be regarded as a minimum; an advantage is therefore gained not only in the matter of quantity, but in quality also, as a public supply improves in purity under the influence of multifold vigilance.

It may be stated as an axiom that water that requires domestic filtration or other treatment is not of fit quality for the supply of a town for domestic purposes. Hence the purity must be of an ascertained high degree, and it follows also that the remedies for excessive hardness or softness must be applied before distribution, and not after; especially for softness, in order to avoid pollution in transit by the absorption of lead from service pipes. Furthermore, water conveyed through pipes requires to be supplied at a constant and more or less high pressure in order to prevent foul gases and liquids being sucked in, and to be always capable of being drawn upon when required. Whether supplied at high or low, intermittent or constant pressure, house cisterns are a necessity in towns possessing a water carriage system of excreta removal, in order to store a reserve supply for the purpose of flushing the water-closets in case the constant pressure be interrupted. Water for dietetic and culinary purposes, on the other hand, when drawn direct from the main, avoids the many forms of pollution due to the material, situation, and connections of cisterns, but this is only possible with a constant high-pressure service. The further advantage of constant high pressure in case of fire is obvious.

The necessary complement to the water-supply is the sewerage, and with the successive periods of growth of a town the questions of disposal also repeatedly recur, the destination being removed from the brook to the river, and from the river to the land. The main difficulty in disposal is not the suspended or dissolved organic matters so much as the excess of liquid, and the variation in its quantity. Sewage in which the liquid is never more than sufficient in

quantity to flush and completely carry away the solid matters committed to it, and therefore comparatively uniform in standard, is necessarily more easily dealt with than when it is liable to great variations in both quality and quantity.

On account of the greater rapidity of removal possible by water- than by land-carriage, opinion is now decided in favour of the former mode of excreta removal, but is still divided upon the question whether rain- or storm-water should be added to waste-water and excremental sewage, or be removed by a separate system of drains and sewers. Whether the drainage system be single or be duplicated, more or less pollution of both takes place, and in both systems it is advisable to apply to the drainage the same precautions against the pollution of air and water in and about dwellings. Provided these precautions are taken equally in both systems, the adoption of a single or of a separate method of removal becomes only an engineering question.

Refuse presents also the periodically recurring increase in difficulty of disposal. The abolition of gardens renders the more frequent removal of domestic refuse from the proximity of dwellings necessary, and more care in storage during retention is called for by the greater limitation of space. The distance of transport for disposal necessarily increases, until it becomes less costly and more expeditious to destroy it by fire within the neighbourhood. Street refuse and manure demand more frequent removal, and the manner of their disposal is governed as much by financial as by sanitary considerations. The disposal of industrial and trade refuse is frequently made a source of profit that acts as a stimulus to its riddance.

The exclusion from the atmosphere of gaseous pollutions produced by manufactures is being more or less effectually compassed, yet the increasing burden of smoke from domestic chimneys remains to be relieved, most probably by the substitution of gaseous for solid fuel as a means of heating and cooking.

But the factor that prevails over and complicates all other problems of urban sanitation on a large scale is the tendency to ever closer and closer aggregation of the

population. The crowding of persons into rooms, of rooms into houses, of houses into blocks of buildings, of blocks into quarters or areas entirely built over, and of such quarters together into towns, is constantly going on. These various forms of crowding can only be hindered by the dedication of areas of land as open spaces or parks between the various quarters of a town; by providing ample thoroughfares, combined with public gardens where requisite, especially between the larger blocks of buildings; by prohibiting a certain proportion of every building site from being built over, and restricting the height of houses in proportion to front and rear space; by prohibiting methods of construction of houses that prevent adequate perflation and ventilation of rooms; and by prohibiting and preventing the cubic space of rooms being overtaxed by occupants.

So far as mere packing goes, the population of the entire world, allowing each individual three square feet, could stand upon the Isle of Wight, and could lie down upon an area about four times as large, and allowing a thousand cubic feet of space per head, could be contained in a cube the base of which would measure considerably under five square miles. By such comparisons the provision of three hundred, or of a thousand cubic feet of space per head is reduced to quite a subsidiary position as a measure of the amount of cubic space necessary for the healthy existence of a community. A thousand cubic feet of space may be adequate under certain conditions, but totally inadequate under others. It depends entirely upon the surroundings of the room, of the dwelling, of the whole house, not only what amount of cubic space is necessary, but whether the cubic space is itself so situated as to be fit to be utilised for human habitation. Of what avail is the provision of a thousand cubic feet of space for a person in a room, if the room itself be so situated or constructed as not to be provided with ventilation and perflation by sufficient air from a reasonably pure source? The answer to this permanent structural question is of far more vital importance than the abatement of temporary personal overcrowding. Personal overcrowding, when suppressed in one place, recurs in another; and it is only in houses under the control of a responsible and fixed owner

or his agent, and which are registered, that the limited amount of air space in a dwelling can be kept permanently uninvaded by an excessive number of occupants. But, in most instances, even these registered houses in large towns are so deprived of light and air that the provision of cubic space is countervailed, and so will it continue to be until the standards of light and air are fixed in a similar manner to the standard of cubic space.

The reduction of the supply of light and air by closer aggregation, both of dwellings and of the persons who occupy them, must lead to the increase of the two main evils against which the practical applications of the science of public health are constantly striving—namely, the spread of communicable disease and the deterioration of health, the latter in turn fostering some of the communicable diseases.

CHAPTER II.

THE DWELLING-ROOM.

As the building block is the unit of the town area, so the house is the unit of the block, the dwelling of the house, and the room of the dwelling. The most important points influencing health in the conditions of the dwelling-room are the dimensions, and the means of lighting, heating, ventilation, and perflation. The question of cubic space in reference to the number of occupants has been already mentioned in the chapter upon chemical media.

It is to be observed that in the construction of the dwelling-house, more or less impermeability of floors, walls, and ceilings, if not the ultimate aim, in each case is the ultimate result, and that they are not to be depended upon for ventilation. The relative permeability of the parietes of the dwelling-house will be entered into more fully later on. As the object in view is to elucidate elementary principles, rather than to enter into elaborate details of construction under varying conditions, it is desirable to confine attention to the simplest form of dwelling-room—a room limited to one door, window, and fireplace, and used as an ordinary sleeping- or living-room, in the manner usual amongst the great mass of workers of a community.

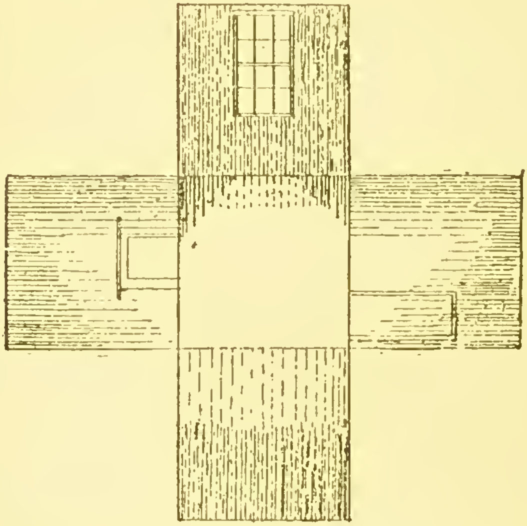
The dimensions of a dwelling-room are dependent upon adequate ventilation and lighting. So far as ventilation is concerned, the larger the dimensions of the room the more it is facilitated, and especially by increased height. The very minimum height allowed by law is 7 feet, but 10 feet must be regarded as a more healthy standard, with any lesser height the difficulties of ventilation are considerably

increased; on the other hand, excessive height, as for instance over 16 feet, tends to cool the warmer and rising impure air, so that it falls again, unless special means are provided for its extraction; but in ordinary dwellings such an excess of height need not be considered. So far as lighting is concerned, the question is, how much cubic space can be adequately lighted by one window? The answer to this will depend upon its size and position.

In hot climates the sun's rays, direct and reflected, are more or less excluded from the dwelling; but as we approach higher latitudes the size, as well as the number, of the windows increases. The proportionate size of the window to the dwelling-room may be variously estimated. Robert Morris[1] lays down the rule that the square root of the cubic contents of a room will give the area of window space required in feet, and the Local Government Board's by-laws require the total window area, clear of the sash frame, to be equal to at least one-tenth of the floor area. The former may be looked upon as a maximum, the latter as a minimum. Trélat[2] formulates the rule that in a dwelling looking upon open space the window should occupy one-fourth of the area of the wall in which it is situated, and the lintel should be as elevated as possible. This not only projects the light furthest, but also facilitates ventilation. In the window of a dwelling-room the bottom pane must not be placed so high as to be above being conveniently seen through in the sitting posture, but the lintel, on the other hand, cannot be extended too high, and preferably should reach the ceiling. Hence, assuming a room to be 10 feet high, and the bottom rail not higher than $3\frac{1}{2}$ feet from the floor, and that the lintel itself occupies a few inches, then the height of the window would be about 6 feet. A very wide window may not only be difficult to manipulate, but combined with height may also lead to unnecessary loss of heat, hence it is not desirable to make a single window wider than will sufficiently light the room it serves; 5 feet would be an excessive, and 2 feet a restricted width for ordinary purposes; 4 feet might be considered a full, and 3 a moderate width.

[1] *Lectures on Architecture.*
[2] *La fenêtre considérée comme source de lumière.*

The depth of a room, according to Trélat, should not exceed one and a half times the height from the floor to the top of the window. This would give an incidence of 30° to the rays of light reaching that portion of the floor furthest from the window; if an angle of 45° were required the depth should not exceed the height. According to the latter proportions, a room 10 feet high would be 10 feet, and, according to the former, 15 feet deep as a maximum. The room should not exceed a width or length that can be adequately lighted along the sides. The light entering



DISTRIBUTION OF WINDOW LIGHT

impinges horizontally on the lateral walls at an angle of 45°, the dark angles on each side of the window diminishing or increasing as the side walls approach or recede, and the width is governed more by the situation and width of the window than by the height or depth of the room. The best position for the window is generally central, and a width of 4 feet may be taken as an ample allowance. In lighting a room in which the depth is proportionate to one and a half times the height, the reflection of light from the side walls is of some consideration in illuminating the furthest points.

The ratio of the width of the window to the width of the room has therefore an important bearing upon lighting. The increase in the area of the triangles of shadow on either side of a window, produced by increasing the width of a room, the width of the window remaining constant, is equal to the increase produced by decreasing the width of the window in the same proportion, the width of the room remaining constant. The less the area of the side wall in shadow the better will be the lighting, and as the angle of wall in shadow in a rectangular room is a right angle of which the contiguous sides are equal, the depth of side wall in shadow is equal to the width of outer wall in shadow. But Trélat formulates that the window should occupy one-fourth of the area of the wall in which it is situated, and as it has been assumed that the window would be 6 feet by 4 feet, or 24 feet square, this would give an outer wall of 96 square feet, and as 10 feet would be the height, 9 feet 7 in. would be the width of such a room.

Thus, for adequate illumination it is undesirable that the space on the outer wall on either side of a centrally situated window should exceed in width the width of the window, and to avoid loss of heat a less width than the width of the window would be contra-indicated. So that practically the width of the room is dependent upon the width of the window, and, according to general sizes of rooms with one window, would vary from 10 to 15 feet.

The window not only serves as an inlet for light, but also when open as an inlet for external air. In the primitive dwelling the entrance and the aperture for light were one and the same, and in the tropics are still so. In colder climates it is found more conducive to warmth that the door should not open directly into the outer air, but into a porch, hall, corridor, or staircase the air of which necessarily gains access to the dwelling-room, and the door of the room becomes more or less an inlet for internal air, hence the necessity for maintaining the general air of the house in as pure a condition as possible. The complement to the window and door, acting as a ventilating outlet, is the open fire-grate, the usual means of warming in this country.

I do not propose to enter into a dissertation upon the

comparative merits of warming by open fires, closed fires or stoves, hot air, and hot water or steam, but rather to indicate the bearing upon health of the usual method in the ordinary dwelling to maintain a temperature of from 60° to 65° F. Our more equable insular climate enables us to resort to simpler modes of heating than the more extreme continental climates demand. The effective ventilation, the cheery appearance, and the healthy radiation of the open fire have weighed so heavily in its favour, that attempts to disturb its sway in the dwellings of this country have never met with any extensive success. Nevertheless, it possesses in its crude form serious drawbacks. It is extremely wasteful of the heat produced, and extravagant of fuel, and the heat being radiant, its intensity diminishes with the square of the distance from its source. At four feet it is sixteen times less than at one foot distant from the fire. The latter is an irremediable condition, but the former defect may be overcome, and no one has done more in this direction, since the time of Desaguliers and Rumford, than Pridgin Teale. The points to be observed are: the back of the grate should be about one-third the width of the front, and the sides should slope accordingly; both back and sides should be of fire-clay, and the back should slope forwards, so as to lean over the fire and contract the throat of the chimney above it; the bottom of the grate should be deep from before backwards, and either consist of a solid slab of fire-clay, or if the under bars be retained, the slits should be narrow, and the space beneath should be closed in front by a shield. The effects of this construction are: to shut off any upward draught from beneath the fire, to prevent too rapid combustion of the whole mass of fuel, and to cause the incandescence to reach the fuel at the back of the grate gradually by extension from the front, the smoke given off during the process being more or less consumed in passing over the fore-part of the fire, when doubling round the projecting back to reach the chimney. The consequence is that fuel is economised and the smoke diminished, and, if at the same time the throat of the chimney is sufficiently narrowed and the fireplace projects well into the room, the draught is increased and the heat better distributed. Although the quantity of smoke may thus be

diminished, solid fuel in an open grate must always continue to produce more or less smoky vapour. Liquid fuel, as well as gaseous, may be consumed in specially constructed grates, and the fumes given off be more or less free from carbon and sulphur compounds. The desirability of relieving our fogs of these two impurities is increasing with the growth of the size of our cities.

Although for temporary purposes, such as cooking, due to the saving in rapid lighting and extinguishing, gas may be cheaper than coal as a fuel, for continuous heating it is dearer, and until the cost is more nearly assimilated to that of coal, it is not probable that it will oust coal altogether from the dwelling. It is coming into more general use, nevertheless, on account of its easier manipulation, more uniform temperature, greater cleanliness, and saving of labour. For its more general use to extend to the poorer classes, its price must be cheapened, and it must be supplied automatically in response to ready payment in every humble dwelling.

The amount of vitiation of the air of the dwelling-room will depend upon the number of occupants, and also upon the kind and amount of artificial light.

The point at which the organic matter of expired air begins to be perceptible to the senses is the standard of purity below which the air of a room is held to be prejudicial to health. By the chemist this standard limit is for convenience estimated by carbonic acid, corresponding to 0.6 volumes per 1000 volumes of air. Fresh air contains 0.4 volumes per 1000; the permissible vitiation therefore is 0.2 volumes; and as an average man gives off 0.6 cubic feet of carbonic acid per hour, it will require $\frac{0.6}{0.2} \times 1000$ or 3000 cubic feet of fresh air to maintain the standard.

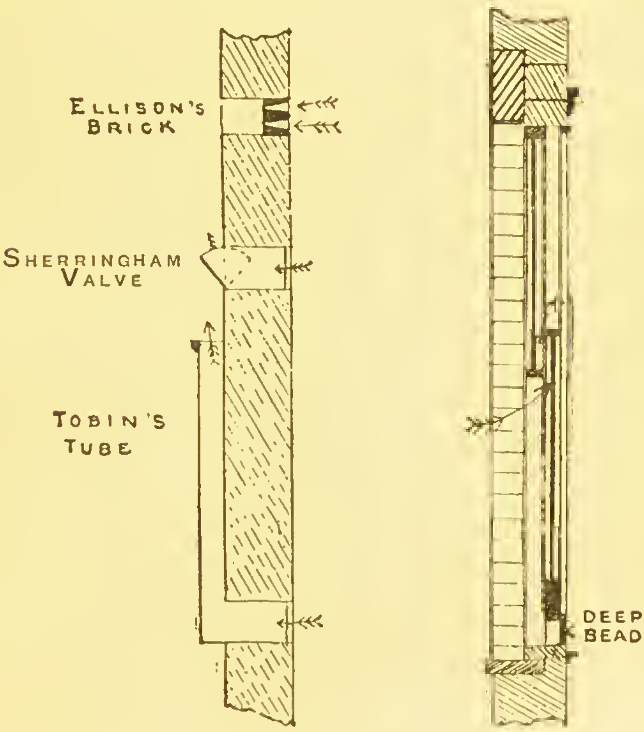
In this climate the air cannot be changed more than about three times an hour without causing a sensation of draught, and hence 1000 cubic feet of space per head are held to be necessary for the supply of 3000 cubic feet of fresh air per hour. But in warm weather, or if the air be warmed, it may be changed more rapidly and somewhat less cubic space may suffice. The volume of air exchanged, or the amount of vitiated air replaced by pure air, will depend upon the temperature, and upon the size of the

inlets and outlets, and not upon the cubic space. The difficulty of ventilating small rooms is due to the diminished space for diffusion, so that the in-coming air-currents are prevented from being broken up and distributed to dilute the vitiated air before coming into contact with the occupants. If the ceiling be moderately high, and special inlets directing the in-coming air upward be provided in proper situations, this may be overcome.

The completeness of the ventilation will therefore depend upon the distribution and diffusion of the in-coming air, and the situation and form of the inlets and outlets. In the type of dwelling-room hitherto considered, the means of ventilation are the window as an inlet for external air, the door as an inlet for internal air, and the chimney as an outlet. The fire opening into the chimney may be simply and inexpensively supplemented by a mica-flap valve outlet into the chimney-breast close to the ceiling; this, when properly fixed and adjusted, rarely permits a reflux of smoke.

The vast majority of town houses are constructed in terraces, with two fronts, and in several storeys, so that the ceiling and three of the walls of the dwelling-room are not available for direct external ventilation. Methods of ventilation through the roof or requiring two outer walls, although useful for some structures, are commonly inapplicable to town dwellings. The window may generally be made to answer all purposes for admitting the outer air. In summer the top or bottom sash is opened, and the condition of the air in the interior of a humble dwelling at that time of year contrasts well with the condition in winter, when the crevices of the window and door are too frequently the only inlets. This class of dwelling is rarely provided with any special inlets, but the more frequent adoption of the inexpensive and simple expedient of constructing a deep bottom bead inside the frame of the window is much to be desired, for use between seasons at least. So that by raising the bottom sash an inch or two, the opening below the bottom bar of the sash remains covered by the deepened bead, but the opening between the upper rail of the bottom and the lower rail of the top sash in the middle of the window is free, and the in-coming

air current is broken at an angle and directed more or less upward. A more expensive and less effectual method of utilising the window is by adapting a glass pane to admit air without opening the window. Double panes of glass, with a space between, the outer cut short at the lower part, the inner cut short at the upper part, are fitted so as to admit air from the exterior between the panes from below the former to discharge into the interior above the



INLET VENTILATORS.

latter. Or, air may be admitted through a glass pane, by a hit-and-miss ventilator, either rectangular or circular in form, or by movable louvres, or by simple slits in the glass.

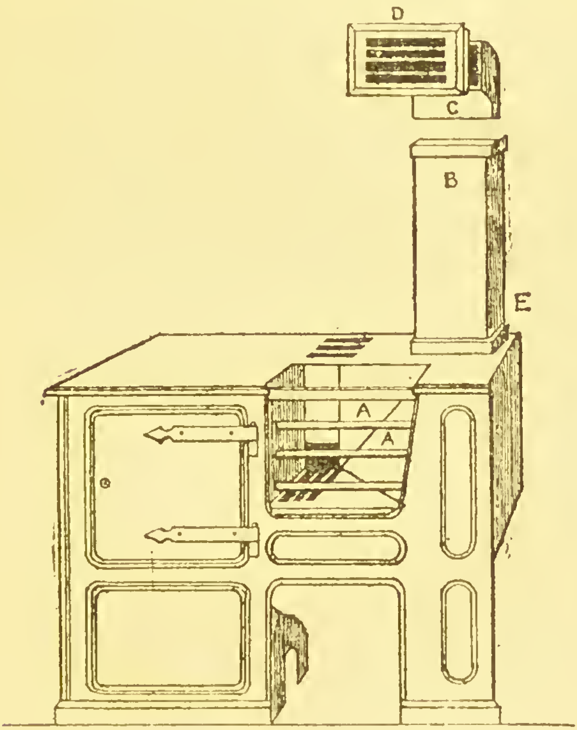
The window, besides acting as a ventilator in summer by wide opening, and between seasons by an inter-sash aperture, in winter acts as an excellent hygrometer, by condensing the watery vapour of the interior air upon the

panes; this streams down to the sash, and is evidence that the production of watery vapour, accompanied by carbonic acid and organic matter, is in excess of the power of evaporation and of ventilation.

Where it is desired to make other communications from the outer air into a dwelling-room, the forms of ventilators in more general use are, the Tobin tube, the Sherringham valve, and the Ellison conical brick ventilator. The third mentioned blows more or less directly in, and may be alternately an inlet and an outlet. The second may also be both inlet and outlet, and if placed too near the ceiling cause a cold down draught; placed two-thirds of the way up the wall it is in the best situation, and in that position it is least liable to act as an outlet. For continuous ventilation there is nothing so desirable as an appliance that can be relied upon to act always in the given direction in which it is intended to act, and hence of these forms the Tobin tube is undoubtedly the most reliable.

But any form of construction is of little value if the occupants are uninstructed in its use, and this applies to ventilating appliances generally. Theoretically they are excellent; practically, in uneducated hands, they become useless. Tobin tubes and Sherringham valves will in the large majority of instances be blocked up in winter, and remain so for the rest of the year. In spite of the objections raised to admitting the air from the interior of the house into the dwelling-room, in practice it is found that in mid-winter the external air is not tolerated, and that resort is commonly had to the door as an inlet when the air of the room is vitiated; for the humble, like the wealthy, prefer the chill taken off the winter air. Confronted with these practical facts, the indication is above all the maintenance of the purity of the air of the interior of the house, more especially in winter, when the outer air is shut off from the room, and the draught of the fire is supplied mainly from the interior. All direct communication with w.c.'s, and with drain inlets in any form, should be rigidly excluded from the house, and the ventilation and cleanliness of staircases and passages enforced. These are far more valuable precautions than the insertion of complicated appliances, for ventilation depends upon the occupier rather than upon any

particular appliance. A notable exception must be made in favour of the ventilating grate—Galton's grate, the Manchester School grate, and Griffin's grate. Fresh air is admitted from the exterior into a chamber at the back of the grate, where it is warmed and thence passes into the room by an opening above the chimney-piece. In working-class dwellings the living-room and kitchen are usually one, and the form of grate required is one that will cook, heat,



HEATING, COOKING, AND VENTILATING GRATE.

and ventilate at the same time. Such a form of grate is in use in married soldiers' quarters in some barracks, and is also well adapted for use in the dwellings of the humbler classes. In summer time, the admission of warm air can be regulated or stopped altogether, by an ordinary valve in the supply tube, without disturbing the kitchen fire for the purposes of cooking. However advanced hygienic methods

may be, the test of their value is the practical use made of them by the multitude. In this regard, it would be necessary that cost should not debar the builder from inserting such grates, and that simple, plain instructions should accompany them. Legislative compulsion is as difficult to apply to ventilation as to smoke consumption, however prevalent utopian ideas may be.

In a dwelling-room without special means of ventilation, and with window and door closed and fire burning, such currents of air as gain access will tend to flow downwards, and along the floor to the fireplace. If there be inter-sash ventilation, or valved inlets in the upper panels, or above the lintel of the door, the in-coming currents would be directed upwards from a point about midway between floor and ceiling, and more or less diffuse before descending to pass up the chimney; and if in addition there be an outlet valve in the chimney-breast near the ceiling, the currents would be still more diffused on account of the tendency of the warm, vitiated, outgoing air above the fireplace to cause a swirl in an upward direction.

The relative positions of the fireplace, window, and door also materially affect the completeness of the ventilation. It is not usual to place the fireplace against an outer wall, that situation being avoided on account of the loss of heat that it entails, and in an ordinarily constructed room the window is not usually situated on the same side as the fireplace. The fireplace is generally constructed in a party or side-wall, and therefore in a terrace-house the window is not usually situated in the wall opposite to the fireplace, but at a right angle to it. Thus its ventilating power is confined more or less to one angle of the room. Although this may vary according to construction, still it suffices to illustrate the points of relative situation of window and grate.

If the window be situated in the same wall as the fireplace, the area ventilated is least; on the other hand, if it be situated in the opposite wall, the area ventilated is greatest; the latter, therefore, so far as ventilation is concerned, is the most desirable relative position, although the most usual is that at a right angle, and is of intermediate merit.

The door, in relation to the fireplace, may be placed in

either of the four walls of the room, but it is not so much its relative position to the fireplace as to the window that is of importance. Organic emanations from the surface of the body and from respiration cling tenaciously to the surfaces of the interior, and of the furniture of a room, and ordinary ventilation is insufficient to dislodge them. Ventilation suffices as it were for current respiratory wants, but more forcible air-streams, which would be unbearable during prolonged occupation, are necessary to purify interiors. This form of air purification is appropriately known as perflation.

Perflation becomes the more necessary the more continuously a room is occupied, on account of the accumulation of organic pollution and the persistence with which it adheres to surfaces and pervades porous substances, especially stuff materials. This pollution becomes aggravated when pathogenic micro-organisms are introduced by an occupant suffering, either in an incipient or a pronounced form, from some specific disease, such, for instance, as the pulmonary form of tuberculosis. The strong organic odour of humanity that persistently prevails, especially during winter months, in rooms occupied by the lowest strata of the social community is most striking to the investigator of such dwellings. It is due to the continuous occupation, and persists even with moderate ventilation, such as can be borne with reasonable comfort to the occupants.

For purposes of perflation the most advantageous relative situation of window and door is in opposite walls, in the long axis of the room, the least desirable in the same wall, and an intermediate condition will prevail when they are situated in contiguous walls. Necessarily, perflation will only take place when the window and door are both thrown open at the same time, but however brief the period necessary, and even a few minutes will effect much, it is difficult to impress the value and desirability of such a measure. The amount of perflation will also depend very much upon the construction of the house, and the situation of the door of the room in relation to the other rooms and the rest of the house,—points that will be considered in reference to back-to-back houses.

As the door of a room must necessarily, whether we desire it or not, be one of the main openings of ventilation and perflation, it follows that rooms approached through adjoining rooms, instead of from the staircase, must be mainly ventilated from those rooms, and the perflation must be more or less influenced by them. This method of construction is largely on the increase in buildings erected in flats, and cannot be conducive to health, unless provision is made for perflation by the rooms being situated on opposite sides of the building. Obviously, the most perfect perflation is obtained when windows exist at both ends of a room, but this is seldom the case.

Both the ventilation and perflation of rooms are materially promoted by the ventilation and perflation of the staircase and passages in to which they open, and hence the constant circulation of fresh air in the well of the house is necessary to maintain a reasonable purity.

CHAPTER III.

THE DWELLING-HOUSE.

APART from geographical, geological, and climatic conditions, the healthiness of the site of the dwelling depends primarily upon the natural water-supply, drainage, and soil. In the open country these are important factors, but in the town engineering and architectural skill overcome natural disadvantages. Water-supply and drainage, and the preparation of the soil and site, effected by mechanical means, deprive originally unsuitable localities of the injurious influences they may have possessed under natural conditions. And although permeable soils of sand, gravel, or chalk, with low ground-water levels, remain the most salubrious, other soils of unfavourable formation and contour may be rendered reasonably healthy.

In preparing the site for building, the surface must be freed from soil contaminated with organic refuse, solid or liquid, and the level of the ground water permanently lowered, if necessary, by subsoil drainage to a point several feet below the foundations. As a rule, in the country, the former will not be called for, whereas the latter will often demand special attention; in the town, on the other hand, while drainage and sewerage will permanently lower the level of the subsoil water, refuse organic matter will frequently be found polluting the soil on and below the surface. It is then, as a preliminary step, specially necessary to remove such polluted soil from the site, that is, to cleanse the surface—a step too frequently neglected in urban districts—and when required, to make the ground up to the proper level with dry, clean materials.

Besides preventing the future contamination of the soil

beneath and around the dwelling by means of air- and water-tight drains, and freeing the surface from refuse, provision must be made in construction for the exclusion of dampness, vapour, and air, from the ground below—that is, the surface must be sealed to prevent the aspirating effect of the higher temperature of the interior of the house, especially in winter, from drawing ground air and moisture from the soil. It is also desirable to cover the surface of the ground external to the building, and adjacent to the walls, to a distance of a few feet with some impervious material, to prevent percolation in immediate contiguity to the external surface of the walls.

The materials used in building construction are either substances more or less impervious to water, or being pervious, so disposed or arranged as to exclude moisture.

Lang[1] gives the following as the results of experiments upon the power of absorption of water by various materials in proportion to their cubic contents or volume:—

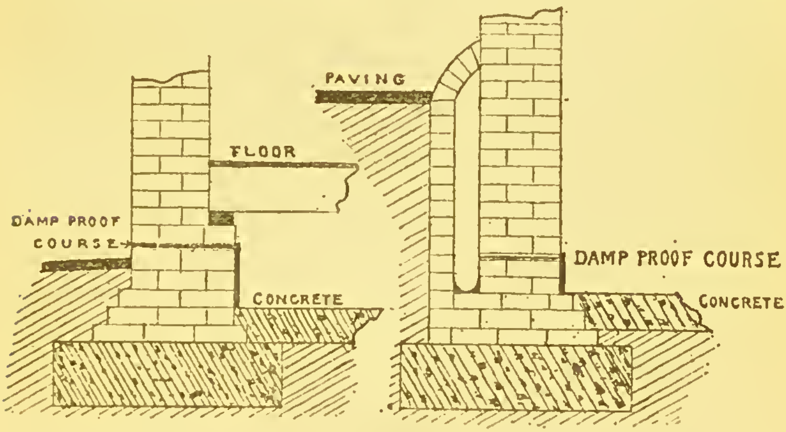
Material.	Percentage of volume.
Plaster of Paris	50.9
Calcareous tufa	32.2
Cement	26.5
Machine bricks	24.9
Mortar	24.2
Sandstone	18.1
Hand bricks	17.9

Bricks are also made less absorptive than the last, and various stones, such as granite, trap, and basalt, possess very little absorptive power, but on the basement interior concrete or asphalt is best adapted for forming an impervious stratum, and stone paving is generally adopted for the surface external to the building.

For the purpose of sealing the surface of the basement of the building, a solid layer of impervious material, usually concrete, is laid over the entire area contained within the walls, and just above the level of the footings that rest upon the foundation, which is also frequently underlaid with concrete. The ascent of dampness in the walls by capillarity from the soil below is checked by the insertion of an impervious or damp-proof course. This course is

[1] *Zeitschrift für Biol.*, xi.

usually inserted a few inches above the external ground-level in order to be beyond the reach of splashing from the surface, and if constructed of plastic materials, is extended down the inside of the wall until it meets the concrete layer, or else the concrete is continued up the internal surace as far as the damp-proof course. The external ground surface is also concreted or paved to the distance of a few feet or more from the wall, especially if the basement is sunk below the surface level, when a dry area also is formed by a retaining wall constructed to hold back the soil from the main wall. This dry area may vary from several inches to several feet in width. The



DRY AREAS.

objection to making the dry area very narrow is the increased difficulty of ventilating below a wooden floor to prevent dry rot, together with the lessened purity of the air admitted; in the absence of a wooden floor, ventilation for this purpose is unnecessary, but the basement then becomes a cellar, unfit for human occupation, and useful only for storage purposes.

The basement is thus rendered impervious to both water and ground air. The walls and roof must also be constructed to exclude water, and the whole building to guard against extreme variations of temperature. Materials that are porous and good conductors are therefore contra-indicated. When materials more or less porous have been used for

walls, it is sometimes necessary to line them externally with impervious materials to prevent the effect of driving rain; this is accomplished, either by a continuous layer of various kinds of cements or compos, or by impervious tiling arranged in an overlapping manner as upon a roof. The general effect of moisture is to render porous materials less pervious to air, and so long as sufficient water is present to seal them completely.

Various opinions have been held as to the desirability of walls being permeable to air. The objects to be gained by such permeability would be ventilation, and the additional non-conductivity obtained by the presence of air in the material. As the latter quality is enhanced by the stagnation of the air, and may be produced by other means, ventilation alone remains in question, and the amount so obtainable may be gathered from Douglas Galton's observations,[1] with an external temperature of 40° F., and an internal temperature of 72° F. The number of cubic feet of air admitted per hour by a square yard of wall were, according to material:—

Sandstone	4.7
Quarried limestone	6.5
Brick	7.9
Limestone	10.1
Mud	14.4

Lang gives the following co-efficients of permeability for various materials:—

Limestone	7.980
Dross	7.596–1.687
Deal	1.010
Mortar	0.906
Ordinary bricks	0.383
Concrete	0.258
Well-baked bricks	0.203
Portland cement	0.136
Compact sandstone	0.130
Half-baked bricks	0.086
Plaster	0.040
Oak	0.006
Glazed tile	0.000

[1] *Healthy Dwellings.*

The results obtained by French observers are summarised by Léon Faucher and Richard in the *Encyclopédie d'Hygiène* as follows :—"The quantity of air that passes through walls, or through the materials, is appreciably proportioned to the initial pressure. The passage of air through permeable materials diminishes very slowly as the thickness increases, and the thickness may be considerably increased without greatly reducing it. A wall of soft stone of half a metre in thickness will allow, under pressures varying between one millimetre and three centimetres of water, from 12 to 350 litres of air per square metre to pass per hour. When the permeable materials are wet they only admit about half the quantity that would pass in the dry state. Cement is but slightly permeable. Marble and wood (in a direction perpendicular to the fibre) are not permeable under pressures below three centimetres of water. Dry plaster, the permeability of which approaches that of soft limestone, is rendered almost impermeable by two coats of paint. The permeability of walls is notably diminished by whitewash, and above all by glue or size, still more by glazed wall-paper, and even by ordinary wall-paper when hung with strong glue or size. Oil colour almost completely prevents the permeability of walls when applied in several well-covered layers and sufficiently dried. Varnish also effectually prevents permeability."

It will thus be seen that the quantity of air passing through even naked walls is so small in volume as to have little effect upon the ventilation of the ordinary dwelling, and since walls are always covered internally, and frequently also externally, it is reduced to a minimum, and becomes practically a negligeable quantity. Furthermore, it is specially desirable that the interior of a dwelling should have impervious smooth surfaces, in order to prevent dead organic matter and living organisms from being retained within or upon them, either by simple deposition or by filtration through their pores.

The roof must, above all, exclude rain and snow, and for this purpose various materials are used—tiles, slates, lead, zinc, galvanised iron. With this end in view roofs are pent, or, when constructed flat, require to be made more carefully water-tight. The water is led from the surface into

gutters and down pipes, which thus protect the walls from saturation. With the exception of certain roofs specially contrived for the purpose of drying-grounds or play-grounds, and consisting then of a solid asphalt or cement layer, the materials of which roofs are usually constructed, and the mode of their arrangement, do not exclude the air, nor is it necessary that they should. The draughtiness and the extreme variations in temperature are overcome either by an interior lining of felt or of wood, generally plastered and white-washed over, or more commonly by a lath and plaster and white-washed ceiling. The interest of this lies in the fact that plaster and white-wash, as already stated, are very impervious to air, so that the amount of air admitted by the ceiling of a dwelling-room so constructed is as negligeable a quantity as that admissible by the walls. This impervious construction of the topmost ceiling in a dwelling-house is of more advantage in modifying temperature than in excluding air, but the ceilings in the lower rooms derive their main advantage from the power of excluding air rather than of modifying temperature, since they form part of the floors of the rooms above them.

In the construction of a floor certain features are important in reference to health. Not only is it necessary that it should deaden the transmission of sound to the room below, except in the case of a basement floor, but certain other objects must be kept prominently in view—the prevention of the passage of air from the room below, the non-absorptive power of the material of which it is composed for liquids, the prevention of the passage of detritus into the space between floor and ceiling, and of the lodgment of *débris* in joints or inequalities of the surface. Wood, on account of its non-conductivity, is the warmest material, and of woods oak is the best, but the most costly. Deal is the wood in most common use; and although it cannot be easily prevented from wearing unevenly, its interstices may be considerably diminished by even laying. The joints may be closely made, or be alternately grooved or tongued, or the crevices closed with strips of wood; by waxing the surface, or, simpler still, by covering it with hot linseed oil, prepared paint, or varnish, the floor may be rendered impervious to liquids and air, and the joints may

be sealed. The collection of organic *débris* in the chinks and below the floor-boarding of dwelling-rooms is a lurking danger insufficiently appreciated. The experiments of Miquel, Emmerich, Carnelley, Haldane, Anderson, and Johnstone show that flooring may become the nidus of disease. The conclusion to be drawn from these researches is that solid floors are most salubrious, and the solid fire-proof floors that are coming more into use are to be commended.

Descending again to the lowest or basement floor, it will depend upon the use to which the rooms are put whether the flooring shall consist of cement, stone, brick, tiles or other similar materials, which are rather cold surfaces for dwelling-rooms, or of wood. If of the former, they may be laid on the concrete, but a wood flooring, unless laid solid, and imbedded in pitch, will require ventilation. This is supplied by means of air-bricks or other openings just above the damp-proof course, so that a ventilated space intervenes between the concrete and the wood. The omission of ventilation will be followed by the growth of a fungus that destroys the wood. Although called dry-rot it is dry only relatively, the cause being the presence of a small amount of moisture in the stagnant air and the access of the inevitable fungus, which grows less readily when the air is in movement, for the air current tends to evaporate whatever moisture may be present. The space below this basement wooden floor is even more liable to accumulate *débris*, and therefore it is rather more, than less, necessary that the surface should be rendered impervious to air and water.

Besides the permeability of walls, ceiling, and floor, their conductivity is also a matter of moment. In order to prevent the loss of artificial heat from the interior in winter, and the penetration of natural heat from the exterior in summer, building materials should preferably be bad conductors.

Douglas Galton gives the following comparative figures, showing the units of heat transmitted, per square foot per hour, by materials of a thickness of one inch, with a difference of 1° F. between the two surfaces:—

Marble, grey, fine grained	28
Marble, white, coarse grained	22
Stone, ordinary freestone	13.68
Glass	6.6
Brickwork	4.83
Plaster	3.86
Brick dust	1.33
Chalk, powdered	0.87
Fir planks	1.37

The non-conductivity of a brick wall increases with its thickness, and, on account of the very bad conductive power of stagnant air, the introduction of a hollow space in the wall increases it still more, and the same applies to floors and ceilings. This space may also be filled in with some material to further increase its non-conducting power; or it may be utilised for the purpose of warming by passing hot air through it, as in M. Somesco's house.[1]

The amount of sun-warmth obtained by the rooms of a house depends upon the aspect; a detached house most desirably faces south-east and north-west, whilst a terrace should preferably face east and west in order to obtain the greatest sunshine. The amount of daylight reaching the rooms will depend upon the proximity of other buildings. It has already been stated that light from without should reach the furthest point of the floor of a properly proportioned room at an angle varying from 30° to 45°. It is obvious that in order to light the lowest room of a house these angles must be projected skywards. Assuming that the lowest windows were at ground-level, and that the houses on both sides of a street or rear area were of equal height, these angles would require the width of the front and rear space to be, in the former case equal to about one and a half times the height of the house, and in the latter equal to the height. The latter is held to be the minimum compatible with a healthy building.

The height of a building should be governed by the depth of front and rear space, and conversely the depth of the front and rear space should be governed by the height of the building. No building should be raised above lines drawn upwards and converging over a proposed site from its extreme limits, including the public way upon which it

[1] See *Lancet*, 2nd July, 1892, p. 41.

abuts, at a definite angle to the surface-level; and conversely, any building proposed to be erected should be required to set out a site, including public ways, the extreme limits of which, back and front, should fall outside lines drawn at a similar angle to the surface from the highest point of the proposed building to the ground. If an angle of 30° to the surface be considered an excessive requirement, an angle of 60° must be regarded as insufficient, and 45° as a mean. The last is the angle adopted in Liverpool, and is that advocated for London. As already suggested, the front space would be of a width at least equal to the height of the building, and either be the public thoroughfare or form part of it.

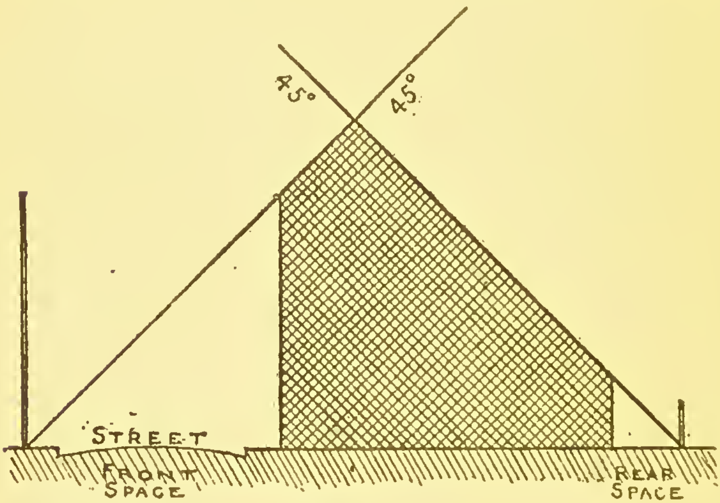
The rear space may, or may not, be in part or wholly a public thoroughfare, provided a sufficient area of open space exclusively belonging to the building be attached to it, for the storage of refuse outside the building, the location of closet accommodation, and other purposes. In detached and semi-detached houses this space may be situated at the side, but in terrace houses it must be situated in front or rear, and if the frontage be at the street-line the rear only is available for its provision. This exclusive space should be proportionate either to the cubic contents of the building, or preferably, to the area and number of storeys of the house, as this would avoid encouraging the construction of rooms of minimum height, and of buildings of increased depth to the detriment of lighting and ventilation.

For instance, an exclusive space extending the whole length of the rear front of the building should be prohibited from being built over, and of a width of one foot for every three feet of depth of the building. For a building averaging thirty feet in depth this would equal a space ten feet in width, practically the present requirement in the metropolis, where no provision has hitherto been made for increased depth or increased height, both of which tend to increase the number of occupants. And as each storey is practically superimposing one house upon another on the same base, an additional space, say of half the width, should be required for each additional storey of the building.

As may be seen by the diagram, the restricting lines for the height of a building would encourage increased depth;

the necessity for providing additional width of exclusive space would in some measure tend to limit this, but insufficiently. A more effectual remedy for preventing the excessive depth of dwelling-houses would be to limit the depth of dwelling-rooms proportionately to the height of the lintel of the window from the floor, and this would secure an additional advantage by encouraging the raising of the lintel closer to the ceiling.

The provision of space both front and back, that is to both faces of the house, is also conducive to aëration as well as lighting, but in order to obtain complete external



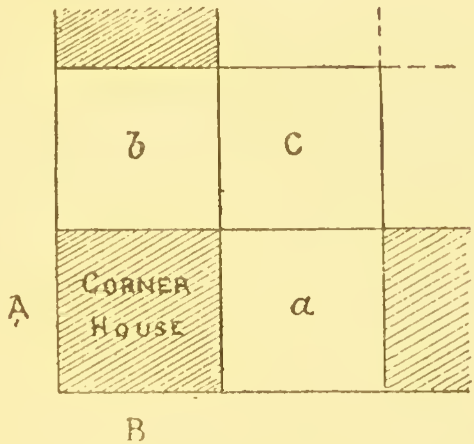
LIMITS OF CONSTRUCTION.

perflation along and between the faces of parallel rows of houses, the space must not be closed at either end, and the less the space is obstructed by out-buildings the greater the free movement of air.

The ideas that have led to the confusion of light and air space, and space for sanitary and other purposes, are typified in Sec. 29 of 18 and 19 Victoria, c. 122, commonly known as the Metropolitan Building Act of 1855, which is still in force in London:—"Every building used, or intended to be used, as a dwelling-house, unless all the rooms can be lighted and ventilated from a street or alley

adjoining, shall have in the rear, or on the side thereof, an open space exclusively belonging thereto of the extent at least of one hundred square feet." In other words, a corner house is expressly permitted to be constructed without any space for sanitary convenience. The section could not have been better framed for the purpose of enabling the rear spaces of a corner dwelling-house to be built over, and the rear fronts to be blocked up.

As a corner house may, figuratively speaking, be said to possess two rear spaces, one should be prohibited from being built over, and the house erected on the other would appropriate the whole, instead of only half, of the space situated at its rear.



a or *b* should be the rear-space of the corner house, and C the rear-space of the house built upon *a* or *b*.

This provision of a small open space attached to the dwelling-house is important from many points of view. Besides its absolute necessity for many sanitary and domestic purposes, it is frequently the only place immediately available, in the humble dwellings of the crowded parts of towns, for the infants and very young children to obtain free movement and a breath of fresh air. Public gardens and parks are usually situated at a distance which renders them more suitable for the older children, and for the adults of those classes in which the mother performs the double duties

of nursing and housekeeping. This has been eloquently insisted upon by Dr. Vivian Poore.[1]

In turning to water service and drainage, it is opportune to point out that many dangers are due to the disregard of the commonest physical principles—that water and other liquids flow down pipes, and that air and other gases flow up, that warm air and gases rise, and that air and gases are drawn into and from pipes by the flow of liquids and the suction of draughts.

The water supplied to the urban dwelling reaches the house through a service-pipe, upon which it is convenient to place a cock for shutting off the supply in case of repairs, and when cleansing is requisite. The service-pipe terminates at the highest cistern, which should be placed at or near the roof. From the cisterns the supply-pipes are led to their several points of supply. These may terminate at draw-taps, or, in tanks, at ball-cocks.

It is a common practice for the cistern supplying water to draw-taps, from which drinking water may be drawn, to be separate and distinct from the cistern supplying water for other purposes. If all closets are supplied with water from intermediate flush tanks, direct connection with the w.c.'s being thus severed, this precaution becomes unnecessary. But it cannot be too strongly insisted upon how desirable it is that all w.c.'s should be supplied either by a separate cistern or by separate flush tanks. That ingenious device attached to many valve closets, by which the basin is flushed direct from the domestic cistern upon raising the handle, and the supply-pipe is closed by an automatic time valve independently of the fall of the handle, evades this precaution. The supply of water to closets by means of spindle valves situated in the domestic cistern, was long since condemned on account of the length of supply-pipe liable to be charged with sewer gas, which entered the cistern as the spindle rose. So also has the supply from the domestic cistern by means of simple taps above the closet basins been condemned, because if the cistern run empty of water, sewer gas may return in its place. Why then incur the risk, however remote it may be, of the same thing taking place with the automatic valve?

[1] *The Concentration of Population in Cities.*

The automatic action may jam and stop the supply of water, or may fail, or, if flushing insufficiently to please the user, be put out of gear, especially since the introduction of hinged seats, and with an intermittent water-supply and an empty cistern, sewer gas in the cistern becomes an accomplished fact. It is only the well-to-do who make use of such appliances, and no hardship would be inflicted by a condition that all water-closets should be supplied with water by a separate cistern or by flushing tanks, whether discharged direct or through a time valve.

Such are the dangers inherent to some supply-pipes from cisterns. Another equally necessary pipe incurs similar dangers, the overflow-pipe. This should terminate in the open air, and every danger from this source may be thus summarily avoided.

Cisterns must be placed where they are least liable to contamination, and therefore should be cut off from the air of the house, but must not be placed where they are liable to freeze in winter. That is, whilst the nearest point to the open air is desirable on the one hand, on the other it is contra-indicated. In fact, the difficulties of properly placing cisterns, of preventing pollution and freezing, and of keeping them constantly cleansed, are so great that they are only borne as the lesser of two evils—deficiency of quality rather than deficiency of quantity of domestic water.

With a constant service of water the necessity for a cistern is reduced to a minimum. The supply-pipes are relieved by the cistern from the pressure the service-pipe sustains, but there is no particular advantage in this, in case of fire it is a disadvantage, and hence hydrants are always fixed on main- or service-pipes. With the constant supply the necessity for a cistern in case of fire disappears, unless the building be immoderately high. There remains then only the question of reserve supply in case of failure of the service.

The cistern capacity requisite depends upon the size of the house and number of occupants. Reckoning upon a supply of thirty gallons per head daily, and a depth of 3 feet for the cistern, ten persons would require a cistern about 10 feet square, twenty-five persons about 15 feet square, and

forty persons about 20 feet square for one day's supply. It is obvious, therefore, that in case of failure of supply, an ordinary cistern can only be depended upon for a certain number of hours, and even if the supply per head were limited to half the amount assumed above, it would only hold out to a second day. The cistern will hold out longer if it be only utilised as a reserve source of supply for the flush tanks of the closets, in case of temporary failure of the water-service, the domestic and dietetic water being drawn from the rising main.

If, under the constant pressure service, in order to avoid the passage of water used for dietetic and culinary purposes through cisterns, draw-taps be fixed upon the rising house main, care must be taken that *all* draw-taps are at the same time removed from connection with the cisterns, as less attention will be paid to their cleansing in future, and extra risk would be run in drinking water derived from them.

As in the water-service, so in the drainage of the house certain fundamental principles must be observed. Without entering into elaborate details of construction appertaining rather to special works upon the subject, these principles may be rendered sufficiently clear by confining attention to the trapping and ventilation of the drains.

The object to be aimed at in the drainage of the house is to completely carry away all water, liquid refuse, and excreta, and at the same time to prevent the air of the sewer and of the drain from gaining access to the house. Excluding for the present the removal of unsoiled water, this is accomplished by means of pipes so constructed and laid as to be impervious and self-cleansing, the openings being sealed by water-traps. A trap is essentially an U bend, of sufficient curvature in a pipe to retain enough water to prevent air and gases flowing up, but permitting a free flow of water down, and so shaped and of such a calibre as to be self-cleansing, and not to syphon out in discharging. It is now recognised as an essential part of an effectual water-trap that the pipe or pipes discharging into or upon it must be partly or wholly disconnected from continuity, and be open directly or indirectly to the air. Hence it may be generally stated that the inlets into all soiled pipes

should be water-trapped, and that pipes discharging into the traps should be aërially disconnected.

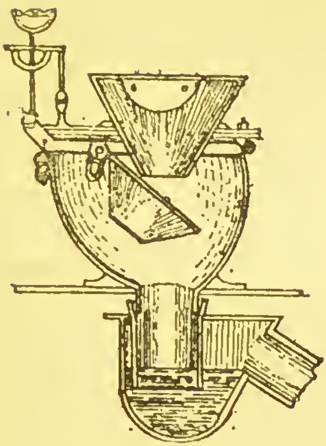
Although a water-trap when charged may arrest the direct flow of gases upward, the contained water may absorb gases in contact with it on one side of the trap and give them off on the other, and a trap may become unsealed either by the water partly syphoning out, or drying up, or by other accidents. Hence branch-pipes discharging into water-traps must also be protected against the ascent of gases by water-traps placed at or near the liquid inflow, when this is situated within the house. So that the general principle prevails that all soiled pipes should be water-trapped at the liquid inflow and open at the liquid outflow. The soil-pipe is an exception to this rule, because it conveys solid matters and is utilised for ventilation, and thus practically becomes part of the house-drain.

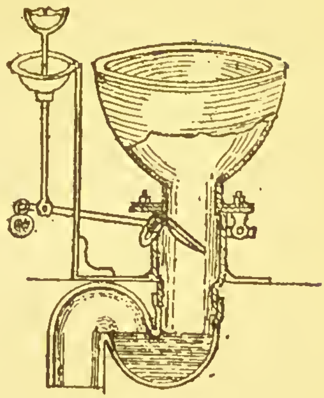
The various pipes to be considered in connection with a house are the cistern-overflow and rainfall pipes; the waste-pipes from baths, lavatories, and sinks; and the soil-pipe, house drain, and portion of drain between the house-drain and the sewer. Commencing from the sewer, the last is generally regarded as part of the house-drain; but constructively it requires to be treated separately by being water-trapped at the house end to exclude sewer gases, the continuity of the house-drain discharging into it being broken, and open directly or indirectly to the air. This is usually accomplished in what is known as a disconnection chamber, constructed of sufficient size to be available as an inspection chamber also. This chamber is open to the air either by a grating, or better, by a pipe terminating a few feet above ground-level, and is the commencement of the house-drain proper, to which it acts as an air inlet.

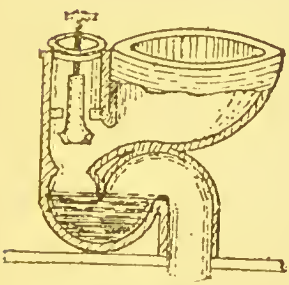
The house-drain must be impermeable to gas and water, and especially secure if running under the house. It must be self-cleansing; this will depend upon the clearness, the smoothness of the surface, the calibre, the gradient, and the flow of water. Every opening into the house-drain must be efficiently water-trapped, and must be situated in the open air or aërially disconnected from the house. It must be through ventilated; this is effected by maintaining the

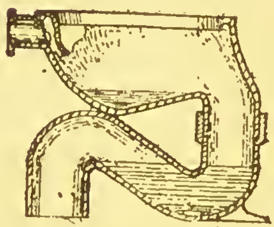
continuity of the soil-pipe with the drain, carrying this pipe full bore to a point above the level of the roof, the higher open end acting as an air outlet, whilst the lower open end of the house-drain situated in the disconnection chamber acts as an air inlet, and a through current is thus obtained. Into this soil-pipe the pipes from the w.c.'s flow, and as they are in unbroken connection with both the soil-pipe and the house-drain, they must be securely water-trapped. But, furthermore, in order to be consistent with the principle that trapped openings in direct communication with the drain must be either situated in the open or aërially disconnected from the house, the water-closets should either be situated outside the house, or else cut off from the air of the house by cross ventilation. A water-closet should be treated as an opening into the drain, and not as a sink, lavatory-basin, or bath, each of which is disconnected from the drain. The situation of a closet against an outer wall, and furnished with a window, supplemented or not by an air grating, will not prevent drain air from being drawn into the house from a defective trap or pipe, if between the closet chamber and the house there be not some means of supplying air to the house, and of thus relieving the in-suction that must otherwise take place through the closet chamber.

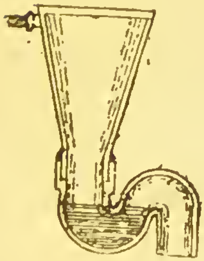
Water-closets are of two main types, according to whether they possess mechanical parts or empty themselves automatically. Of the mechanical type the modern representative is the valve-closet, an improvement upon the old pan-closet by the substitution of a water-tight valve for the pan, a valve-box for the pan-container, and some form of trap, that does not syphon out, for the D trap. Of the automatic type there are two kinds, the wash-out and the wash-down. The former kind is a derivative from a mechanical type in which the valve is placed at the side, the plug closet; by the abolition of the mechanical valve and a slight alteration in the shape of the basin, this becomes a wash-out. The latter kind was originally an improvement on the old form of long-hopper, but its more recent shape may also be regarded as an improvement on the wash-out, by the abolition of the angle that supports the upper water-pool, leaving only one water surface and offering less resistance to flushing.

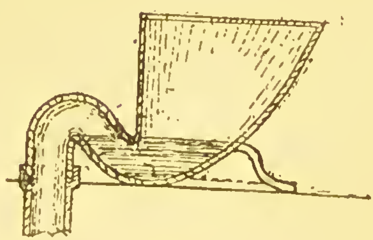

PAN-CLOSET.


VALVE-CLOSET.


PLUG-CLOSET.


WASH-OUT.


LONG-HOPPER.


WASH-DOWN.[1]

[1] The flushing rim and nozzle have been omitted from this diagram.

Wash-out basins, unless they possess an additional under-wash, are not so readily flushed as wash-down and valve-closets, and the double bend retards the force of the water. A good pattern of wash-down or of valve-closet is to be preferred; the disadvantage of the former is noisiness, and of the latter the additional expense of the mechanical parts, which are liable to get out of order, the noisiness of flushing the trap in this form expending itself within the valve-box. The choice of pattern, therefore, is a matter of refinement, and the wash-down answers all the requirements of health, provided that the basin is so shaped as to avoid being soiled, is self-cleansing, and possesses a flushing rim for the purpose of distributing the flow of water over its entire surface. The simplest method of providing for leakage, or the accidental stoppage of a closet-trap, or bath-waste, and consequent overflow, is by a metal tray or "safe," or an impervious flooring below, sloped so as to drain through a pipe discharging into the open.

Whereas all water-service pipes supplying pure water should run inside the house in order to protect them from frost, all drainage pipes should run outside, in order to reduce to a minimum any risk that might be incurred by defects.

Soil-pipes, as already mentioned, should be in continuity with the drain, and be carried full diameter to the roof, on an outside wall, to act as outlet ventilators to the drain.

Waste-pipes from sinks, lavatory-basins, and baths must be trapped at or near the inflow within the house, and be open at the outflow without the house, discharging over or near a water-trapped inlet into the drain; they are thus doubly protected.

As to pipes carrying unsoiled water, rain-water pipes require no traps, but simply to be open at the head and at the foot, both openings being outside the building. Cistern overflow-pipes should simply discharge into the open, and be cut off short a few inches from the wall they emerge through, remote from all chance of gaseous emanations.

CHAPTER IV.

CLASSES OF DWELLINGS.

A BRIEF account of the variable conditions under which dwellings are constructed and occupied is necessary in the first place.

Dwellings may be movable or fixed. Movable dwellings embrace tents, vans, caravans, and temporary sheds and huts; and on the water, canal-barges, boats, and ships. Fixed dwellings are contained in various forms of permanent houses, and a dwelling-house may be detached, semi-detached, or in terrace, and in single or multiple occupation. The occupation may be nightly, weekly, quarterly, or longer; but special attention is necessarily directed, from a public health point of view, to dwellings occupied on the shorter tenancies. Omitting for the present back-to-back, stable, and cottage dwellings, dwelling-houses may broadly be divided into those constructed for occupation by one family as a single dwelling, or self-contained dwelling-houses, and those specially constructed to contain more than one dwelling. A dwelling-house originally constructed for occupation as one dwelling may ultimately become a tenemented house, occupied in separate tenements of one or more rooms by separate families or persons. The effect of this making down process is that the whole house becomes crowded to excess; the basement rooms are occupied as underground dwellings, the garrets and outbuildings are similarly turned to account, the sanitary conveniences, water-closet, and dust receptacle, sufficient only for one family, become overcrowded; the scullery and wash-house become insufficient and difficult of access, wash-houses even being frequently found converted into dwelling-rooms; and in the

absence of a resident owner or agent the condition of every place and thing used in common is neglected.

When this class of dwelling-house is converted into a nightly lodging-house with separate cubicules, or into a common lodging-house with a common dormitory, in both of which cases the living-rooms and sanitary arrangements are used in common, the presence of a responsible resident mitigates some of the abuses and neglectful acts that otherwise grow up, however capable of adaptation the original structure may have been for the purposes to which it has become devoted. Another advantage possessed by houses converted into these forms of common lodging-houses, rather than into tenement houses, is that the underground rooms are not occupied as dwellings, but are generally put to other uses. The situation of underground rooms specially subjects them to obstruction of light and air, and to dampness.

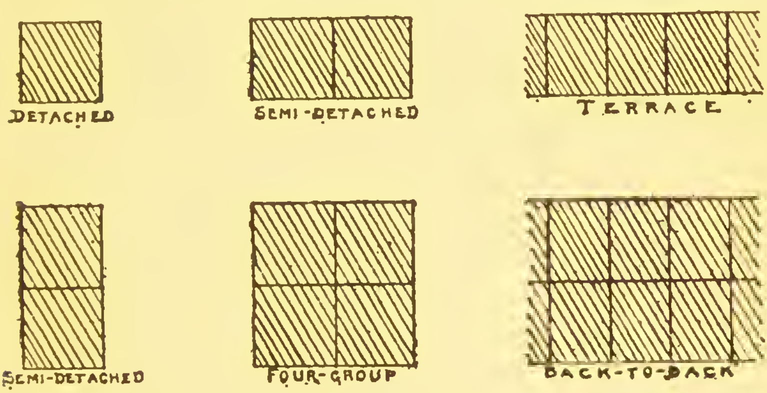
An underground room, that is a room the floor of which is more than three feet below the surface of the street or ground adjoining, is prohibited by the Public Health (London) Act of 1891 from being occupied as a separate dwelling,[1] unless it possess the minimum requirements of a dwelling-room, and in addition, the ceiling at least three feet above ground-level, and an open paved dry area at least four feet wide from six inches below the floor of the room upwards, and extending along the entire front. Here, as well as in building acts and by-laws, no provision is made to prevent the light and air being shut out by the erection of high buildings upon the other side of the area, a condition that largely prevails at the back of houses, and which requires some measure of prevention. The most effectual means of providing against this evil would be by defining a minimum angle at which the light should fall upon the windows of dwelling-rooms, when within a defined distance of other buildings.

Dr. James Russell has ascertained that in Glasgow 24.7 per cent. of the population live in one room, and 44.7 per cent. in two rooms. The census has not yet disclosed the proportion of one and two-roomed dwellings in the metropolis. A large family, even in two rooms, would occupy both more or less continuously, but in one room the

[1] If let in conjunction with one or more rooms above the basement, the Act may be evaded.

occupiers, be they few or many, in most cases live night and day in the same atmosphere. Under these circumstances the opportunity for proper ventilation and perflation is small during the winter months; hence it becomes of importance that the external relationship of the window and door of the room should be such as to encourage to the utmost the entrance of light and air.

An ordinary house constructed in the rectangular form possesses four sides, which may be distinguished as the main-front, the rear-front, and the flanks. Either of the sides may be pierced by openings, windows, or doors, or may be a blind wall without voids. Unfortunately, the terms single-fronted and double-fronted are applied respectively, to houses possessing a front on one side, and on both



sides of the front door, on the same face of the building. As there exists no clear term to define the side of a building pierced by openings, in order to avoid confusion, it is necessary either to invent one or to use some common term in a strictly defined sense; the latter appears the better course. Therefore the term "front" will here be restricted to those sides of a building pierced by openings, so that we may have a fore-front, a rear-front, and a flank-front, and may speak of a one, two, three, or four-fronted building, without confusing them with single- and double-fronted houses. The expressions may not be elegant, but they are at least clear and comprehensible, and enable the subject to be handled with lucidity.

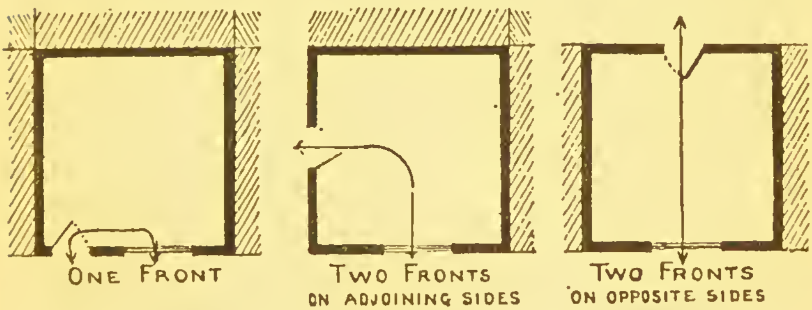
Houses may be wholly detached, with four exposed sides, or may be semi-detached, with three exposed sides, or may be constructed in a row or terrace, with two sides exposed. In the two latter instances they are constructed flank to flank; but they may also be constructed rear to rear, or back to back, with the exception of the detached house, for if upon the back of a detached house another house be constructed, it becomes a semi-detached pair; but two pairs of semi-detached houses backing on each other become a group of four, and two rows of houses back to back become true back-to-back houses. From the number of exposed sides it can readily be understood how many sides pierced with openings, or true fronts, it is possible for each house to possess. A detached house may have four fronts, a semi-detached three, and a terrace-house two; on backing upon each other these are reduced respectively to three, two, and one. It is necessary to distinguish the difference between the two fronts of the terrace-house and the two fronts of the house in the four group; in the former they are on opposite, in the latter on contiguous sides.

It has already been shown how little pervious to air the parietes of houses are, as usually constructed and finished; hence for practical purposes, whether rows of terrace-houses are constructed back to back, or face to face and with a thoroughfare between the rows, provided they possess only one true front, the conditions of interior perflation are similar. This point is important, as showing that the presence of only one true front is the *fons et origo malis*, so far as through ventilation or perflation is concerned.

In the occupation of a dwelling-room the organic effluvia given off by the occupants, and the organic matters brought into the room, be they chemical or biotic, saprophytic or pathogenic, cling to the surfaces. This can be easily verified by the naked eye in scanning or cleansing polished surfaces, and be demonstrated with accuracy by chemical and biological experiment. Ventilation may suffice to dilute the air of a room to a healthy respirable standard, but to maintain the healthiness of the room more thorough aëration is necessary from time to time. The cleansing of

surfaces materially assists to remove deleterious organic matters, but the most beneficial results are obtained when this is supplemented by perflation; the cleansing usually is so supplemented, for it is a matter of common experience how undesirable it is for the cleansing to take place with closed windows and doors, and even without cleansing the purifying effects of open doors and windows for short periods is readily appreciated.

As before stated, whereas ventilation proceeds ordinarily from window and door to chimney, perflation or through ventilation takes place between window and door, and the passages participate in the process. Necessarily, perflation of a room takes place most directly and most abundantly when the door, as well as the window, opens directly into the outer air, and when they are situated at opposite sides of a room

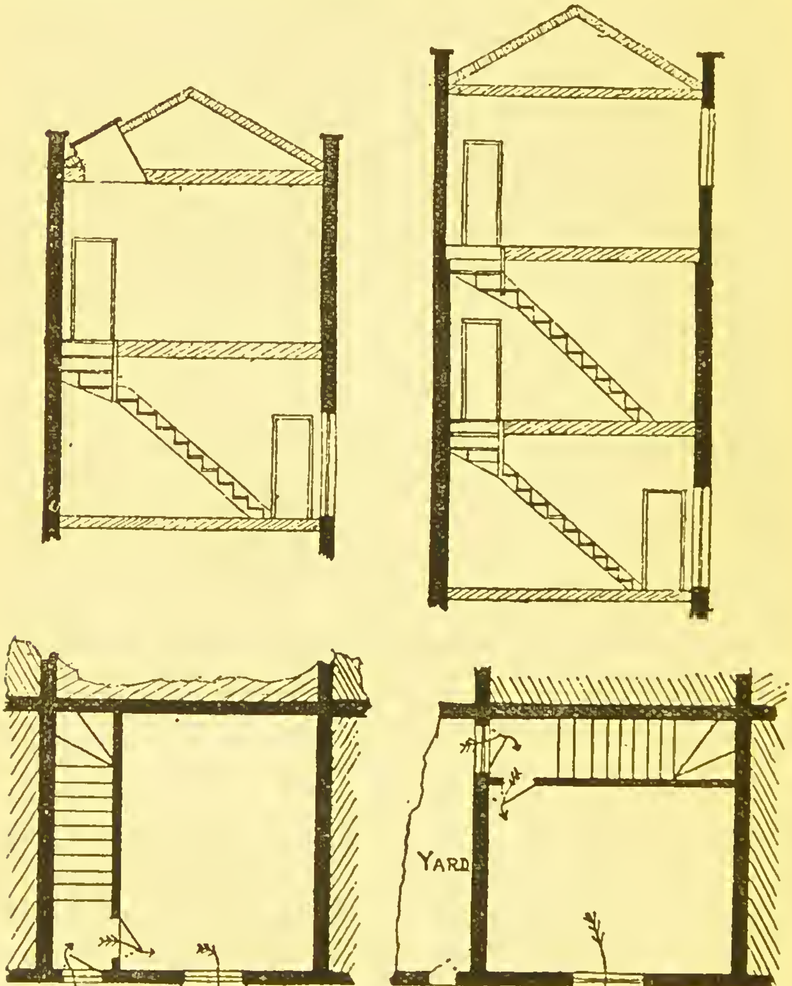


in its long axis; whereas it cannot be said to take place at all when the door and window are on the same side, and only partially when they are situated on contiguous sides. This is illustrated in the three classes of houses possessing respectively one front, two fronts on adjoining sides, and two fronts on opposite sides, and is best seen when there is no passage to complicate the direction of the air-currents.

Two fronts on opposite sides permit of through ventilation; two fronts on contiguous sides allow of diagonal ventilation, or partial perflation; but with one front no perflation at all is possible.

In a house with but one front the addition of a passage tends still more to obstruct perflation, firstly, by diverting

the air-currents, and secondly, by interposing another door. If the house be of more than one storey a staircase is necessary, and in the absence of the second door or of a



BACK TO BACK FOUR GROUP

passage-way, the staircase would be open to the room below, which would then ventilate into the room above. Hence a shut-off passage and staircase and a second door are necessary if the house with a single front is raised more

than one storey high, and perflation is then reduced to a minimum. If an attempt be made to obtain perflation of the staircase, the only means available is by a skylight at the top in an inaccessible position, so that it cannot be opened with facility, even if hinged, and consequently remains permanently closed. It is rare to find accessible mechanical appliances for opening skylights fitted to this class of house, and it is not until the house is raised to three storeys that it is possible to obtain a window on the staircase. In that case the staircase well will be double width, to enable the return staircase to be made from the first to the second floor, the first landing being at the back and the upper landing at the front, so that the front door and the staircase window are both in the same front still. Although there is opportunity for the staircase to be better ventilated, the conditions of perflation of the rooms remain essentially the same, whilst if the house is occupied by several families the probability of front door and staircase window being open at the same time is remote. If the staircase be central, and there be rooms on both sides, the conditions become worse, on account of the increased number of occupants and the more divided responsibility.

In houses with two fronts, as already observed, they may be disposed on opposite or on contiguous sides. In a group of four houses backing upon each other in one block, if only one of the sides in each house be opened up as a front, the condition of perflation is the same as in a true back-to-back house with one front only. When the two contiguous exposed sides are true fronts the conditions are somewhat improved if the staircase is situated on the opposite side of the house to the windows of the rooms, as the doors of the rooms are then on opposite sides to the windows, and more complete perflation of the rooms may take place. But the perflation of the staircase, upon which the perflation of the rooms depends, remains under the same conditions as in the house with one front. That is, in a two-storeyed house the staircase terminates beneath an inaccessible skylight, and in a three-storeyed at an accessible window on the same side as the front door, and is dependent upon the concerted action of the occupants of the ground- and top-floor for perflation. Nevertheless, the opportunities for perflation of

the rooms are materially increased, because the front door is situated in a lateral position, and is approached through the yard or diminutive garden usually attached to a house so constructed, and there is therefore less inconvenience in the door remaining open, inquisitive passers-by being unable to peer in, and promiscuous intruders being excluded by the outer gate, annoyances that lead to closing of the front doors of houses with single fronts.

When we reach houses with two fronts on opposite sides a more improved condition prevails, which permits of direct perflation on each floor independently, from fore-front to rear-front by the windows and doors, a condition which also permits of perflation of the staircase on each floor independently. In houses with more than two fronts the possibilities are greater still.

Besides the absence of through ventilation, a house with a single front may suffer from another grave evil, the absence of open space belonging exclusively to the house. It is necessary to distinguish the open space about a house which may be public way from that which is reserved for private use. The old English word "yard" is derived from the Anglo-Saxon *geard*, a courtyard, and the Danish *gaard*, and expresses clearly the more or less enclosed area girding a house on one or more sides, which may be paved or unpaved; and in this sense a yard will be spoken of. Within the yard-space of a house may be placed the w.c. or privy, the ash and refuse receptacle, and also the wash-house; but the scullery and wash-house are frequently combined and within the house, the yard-space being utilised as drying-ground.

The yards of back-to-back houses constructed in terraces can necessarily only be situated in front, if they exist at all. When they do not exist, the w.c.'s or privies and ash receptacles are grouped together at a distance, generally in a line with the buildings. The disadvantages of this arrangement are, the distant access for the occupants of the houses, the more or less public exposure, and the promiscuous use to which they are liable. On the other hand, if the houses are provided with front yards, and the sanitary conveniences are situated within them, although the disadvantages are diminished, they are not sightly objects, and the wish for their

removal, in order to widen and improve the thoroughfare, may lead to their removal to a less desirable situation, from the point of view of health. Assuming that the sanitary conveniences, whether grouped at a distance or in front yards, be removed to a site created by the demolition of every third house in a terrace of back-to-back houses, the conditions then are improved to the best possible, short of total demolition of the row, so far as sanitary conveniences are concerned, but the absence of perflation of the houses themselves still remains—they possess only one front. The amelioration would therefore be inadequate, unless means were adopted at the same time to open up the exposed sides, and even when this is done to the fullest extent possible, the condition of perflation is inferior to that of houses with two opposite fronts, termed appropriately through-houses.

The effect of the introduction of the water-carriage system of excreta disposal, and of the widening of thoroughfares bordered by back-to-back houses, tends to the removal of sanitary conveniences situated in front, and the abolition of front yards, the only exclusive space available for the occupants. A privy must of necessity be in the open air, but a water-closet and refuse receptacle, together with the sink and copper, may be relegated to the interior of the building, and by excavation below the surface even to a dark, dank basement. This improvement for the worse is within the writer's actual experience, and the possibilities of such cases are additional reasons for the prohibition of back-to-back houses.

Even in a dwelling-house with yard space at the rear it not unfrequently happens that the rear wall of the house, with the exception of the door on the ground-floor or basement leading into the yard, is unpierced by openings. This is a fault that may be easily remedied by additional windows or mechanically worked skylights, so as to procure through ventilation on each floor above.

Dr. Tatham, of Manchester, when Medical Officer of Health for Salford, compiled mortality statistics for the five years 1879-83, of each of the census enumeration areas of that borough, two of the registration districts of which contain back-to-back houses—namely, the Regent Road

and Greengate districts. The areas of these districts classified in groups contrast significantly with each other.

In the Regent Road district the houses, occupants, and sanitary conditions varied, especially in group I., in groups II. and III. less so, and showed the following mortality :—

Groups.	Number of Enumeration Areas.	Percent. of Back-to-back Houses.	Population.	Death-rate per 1000 of Population per Annum.				
				All Causes.	Principal Infectious Diseases.	Phthisis.	Other Pulmonary Diseases.	Diarrhœa.
I.	72	0	54,264	26.1	4.9	2.7	5.7	1.54
II.	10	18	8,773	29.1	4.9	2.7	7.5	1.85
III.	6	50	4,380	37.3	7.6	4.5	8.6	2.83

In the Greengate district the houses, occupants, and surroundings were more uniform, in fact practically similar, and, with the exception of through ventilation, the back-to-back houses were collectively in a better sanitary condition than the through-houses; the comparative mortality was as follows :—

Groups.	Number of Enumeration Areas.	Percent. of Back-to-back Houses.	Population.	Death-rate per 1000 of Population per Annum.				
				All Causes.	Principal Infectious Diseases.	Phthisis.	Other Pulmonary Diseases.	Diarrhœa.
I.	9	0	8,713	27.5	4.5	2.8	6.6	1.42
II.	13	23	11,749	29.2	4.8	3.3	7.8	1.55
III.	12	56	11,405	30.5	6.2	3.6	7.9	2.12
One area of group III.		100	892	38.4	8.7	5.2	9.2	3.36

The progressive increase of mortality, in proportion to the percentage of back-to-back houses, is here distinctly marked.

During an epidemic of measles that prevailed in Leeds in the first quarter of 1890, Dr. Spottiswoode Cameron, the

Medical Officer of Health, found that of the houses in which 172 patients died, 84.9 per cent. were back-to-back, and 15.1 were in through-houses, and of those in which 175 others sickened, 76.0 per cent. were in back-to-back, and 24.0 per cent. in through-houses.

Mr. Butterfield, when Medical Officer of Health for Bradford, in his annual report of 1878, stated that during an epidemic of diarrhœa in that year 101 houses, in which deaths had occurred, were visited. Of these ninety were back-to-back, two cellar dwellings, and nine through-houses; and that of the back-to-back houses, sixty fronted the street, and thirty the back-yards. "Why the deaths should be twice as numerous in the front houses than in the back ones, which face the privies and ashpits common to both, is not easily accounted for, unless the more ready access to the convenience induces a more frequent and prompt removal of the excreta than is the case in the front houses. I have frequently remarked that rather than pass through the portions of street and passage necessary to reach the proper receptacle, women will conceal excreta in some obscure corner of the premises until nightfall. The effect of thus contaminating the already sufficiently close atmosphere of a back-to-back house is of course exceedingly prejudicial to a child suffering from the effects of bad nursing and improper diet. More especially is this the case where the obscure corner before-mentioned is beneath the shelf on which the milk is kept."

The valuable joint report by Dr. Barry and Mr. P. Gordon Smith, F.R.I.B.A., on back-to-back houses, made to the Local Government Board in February 1888, and from which some of the preceding facts have been gathered, concludes thus:—"As a general result of the present inquiry, we venture to submit the following propositions:—

"(1.) That the practice of building houses without provision for through ventilation is still in vogue to a considerable extent in many Yorkshire towns; that in some districts the proportion of such houses to houses provided with means for through ventilation is very large, and is steadily increasing.

"(2.) That the erection of houses upon the back-to-back principle, in the way commonly practised, tends to promote

the huddling of houses, and the consequent crowding of persons upon an area to a degree which is incompatible with health.

"(3.) That so far as structure is concerned, certain facilities exist in back-to-back house construction under which the efficiency of party-walls may be less than in the case of through-houses, but that otherwise the details of house construction generally are similar in both classes of houses.

"(4.) That little or no improvement has taken place in the ventilation of back-to-back houses themselves, and that this applies even in districts where, under comparatively recent regulations, not more than four or eight houses may be built in one block.

"(5.) That improvement in the method of excrement disposal has continuously gone on in the districts visited, but in this respect much still remains to be done. In some cases grave disadvantages to decency and health accrue from the custom still prevalent in certain districts of grouping privies in blocks at an excessive distance from the houses, a practice which is still more objectionable when each such privy has to serve the inhabitants of two or more houses.

"(6.) That the accommodation afforded in through-houses is usually superior to that afforded in back-to-back houses of a similar extent.

"(7.) That the difference in the cost of construction of a through-house and of a back-to-back house respectively, each affording the same accommodation, and built equally well, is very slight indeed; the advantage, such as it is, being with the back-to-back house.

"(8.) That it appears probable that the want of through ventilation has *per se* an unfavourable influence upon health, and gives rise to an increased mortality from pulmonary disease, phthisis, and diarrhœa; but that further and more exact information under this head is desirable.

". . . Without assuming for our report that it finally decides all questions that may arise concerning the construction and wholesomeness of this class of house, we submit, as the general outcome of the inquiry, that the Board should refuse their sanction to any by-laws which

would permit the erection of back-to-back houses, and that they should discourage by all the means at their command the erection of such houses."

From these propositions it will be seen that the main fault of construction in back-to-back houses is the want of perflation, and that this want of through ventilation in a house has *per se* most probably an unfavourable influence upon health; and that the arrangement of back-to-back houses produces overcrowding of houses on area, with deprivation of proper curtilage, and inadequacy of sanitary conveniences.

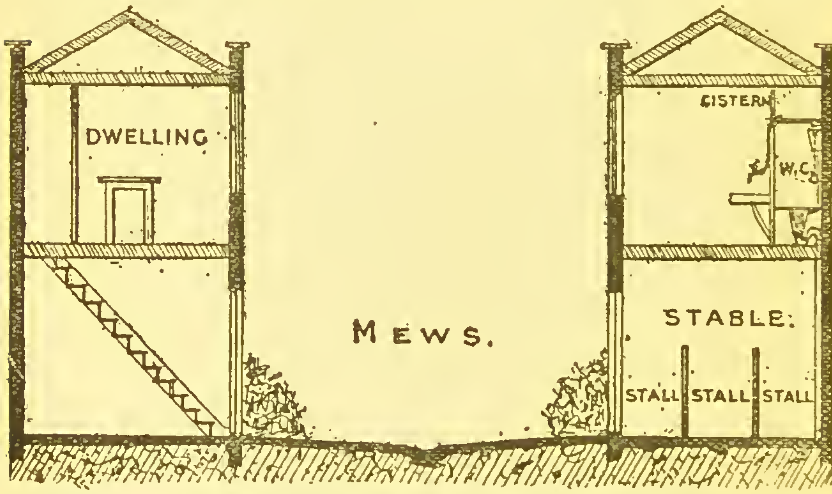
These defects point to the following conclusions:—(1) that the construction of houses with only one true front should be prohibited; (2) that every new house should be required to possess at least two open fronts; (3) that houses with the two open fronts on contiguous sides, that is, houses in groups of four and corner houses, should have certain restrictions placed upon them; (4) that every house should have attached to it an open yard, exclusively belonging to it, and extending the whole length of one of its sides, upon which no structure excepting a W.C., ash-receptacle, or wash-house should be erected.

Some of the worst types of dwellings constructed with only one front, that is, on the back-to-back principle, are those occupied over stables. Stable dwellings are commonly found to be situated in buildings with but one true front, constructed in rows or terraces lining both sides of a mews, and with only the roadway available as open space. When this roadway is converted into a thoroughfare, even the use of this open space is denied. So that the condition of such dwellings becomes even worse than that of back-to-back houses. To an absence of through ventilation and curtilage, are added the conditions inherent to dwelling over animals, and to storing water in such situations.

Dwellings over cow-houses are prohibited, mainly because cows are food-producing animals, and milk specially demands protection. Animals not only foul the air by respiration and exhalation, but their intestinal gases and excreta add to the general contamination. A horse fouls by respiration at least twice as much air as a human being. It is recognised as undesirable for drain openings to exist

within a cow-house, and still more within a dwelling-house, but this condition almost invariably prevails in stables. The stalls in the majority of town stables are deficient in ventilation, and most frequently the stairs to the dwelling above are within the stable; even when this is not so, the separation from the stable is of loosely-constructed materials, and the ceiling and floor above is open-jointed, so that dwelling over, approaches very closely to dwelling in, a stable.

The absence of back-yard or other exclusive space commonly leads to the construction of the W.C. under the stairs beneath the dwelling, and if removed to the upper floor it



is difficult to place it in a position free from risk. There is not usually any difficulty in getting rid of the solid refuse, as it is cast upon the dung-heap; but this again is usually situated immediately below the windows, and if not very frequently removed becomes a nuisance; and the difficulty is sometimes further increased by the conversion of such mews into thoroughfares, the construction of footways at the side, and the prohibition to deposit manure thereon.

Lofts over stables, intended only for storage, are constantly being converted into dwellings of a most unsatisfactory type, receiving the exhalations and effluvia from

animals, closet and drain openings, and are without through ventilation, the skylight, if any, being so situated and fitted as to remain permanently closed. It is only in the height of summer, when all doors and windows are open, that the air of many such dwellings is of a respirable quality. Even new-stables with dwellings over are being erected without regard to the proper requirements of human habitation. The occupation of stable-dwellings, like that of cellar-dwellings, requires to be regulated, and new stables intended to be used as dwellings should either be classed as dwelling-houses, or be placed under special building by-laws.

The causes that may render a dwelling-house dangerous or prejudicial to health are so numerous, and vary in such a degree, as to be incapable of complete enumeration and exact definition. They may proceed from an ill-chosen site, from originally bad construction, either in plan or in materials, from subsequent decay and want of repair, from nuisances of many kinds, and from altered surroundings prejudicial to health.

The increased value of land produces two effects upon dwelling-houses in towns. The original cottage-dwellings become surrounded and hemmed in by higher buildings, to the exclusion of light and air. Who shall decide which are the sinners, the old or the new buildings, in the absence of any definite legal restriction upon the obstruction of light and air to windows and buildings? Until a definite minimum angle of light and air is adopted, to which every dwelling-room window should be entitled, this question must remain to be decided by the present complicated and frequently oppressive legal processes. To establish the right of light and air is a costly procedure in the absence of any definition of what constitutes light and air. The other effect is that which follows upon the reconstruction of higher buildings upon the sites of the original cottages, and is generally the retort to the higher construction of surrounding buildings. The increase in ground value that renders this remunerative in the centre of towns ultimately causes the lower floors to be too valuable for dwellings, and only the uppermost become so occupied. It is an advantage to the dwellings, but not to the workshops and offices, since the street becomes propor-

tionately narrower to the heights of the houses, and we are driven further back to ask whether, in the ever-increasing congestion of town centres, it is possible to supply adequate light and air to places used for human habitation, other than as dwellings. At this point of development very debatable ground is reached, but antecedent to this, the close proximity of large and small, high and low buildings with inadequate space, air, and light for the dwellers therein, converts otherwise healthy dwellings into abodes unfit for human habitation. The altered surroundings degrade the occupants, nuisances arise or are created, the owners lose heart, and want of repair is followed by absolute decay.

As the law at present stands, the onus is cast upon medical officers of health of pronouncing whether a house is unfit for human habitation, and also in certain cases whether a house is properly constructed for dwelling purposes. A house may consist of one or of many rooms, and may contain one or many dwellings. It is quite possible for a room or rooms to become unfit for human habitation without necessarily rendering the whole house unfit, and it is to be regretted that this is not more clearly recognised in legislation. An unfit room may be situated in any part of the house, from garret to basement; take the case of basement rooms that are not technically underground rooms; such rooms may be unfit for human habitation, but can only be taken together with the whole house, yet if the basement windows and doors were removed the condition of the house would be that of being built upon an open basement, with a complete through draught. Again, it is easy to conceive that one room in a house by the exclusion of light and air, or by other causes, may be rendered permanently unfit as a sleeping room; but there is no power to prevent it being so occupied, except by dealing with the whole house. The necessity for the power to deal, within defined limitations, with light and air increases with the growth in the size of buildings.

The internal construction of new dwelling-houses has within recent years improved apace, but the external requirements have remained more or less stationary. Buildings in the great towns and cities are becoming larger and larger, and contain more and more occupants, so that it is

evident that building restrictions must in future be imposed on a larger sliding-scale proportionate to the size of buildings.

Two classes of new dwelling-houses promise improvement in future construction—common lodging-houses and houses let in separate dwellings. The improved plans of a type of the former prepared for the London County Council should have a material effect in fixing the requirements of this class of dwelling-house. Provision is made on the ground floor for entrance, office, day-room, dining-room, kitchen, and scullery; passage and yard, feet troughs, lavatories, urinals, water-closets, baths; receiving-, washing-, drying-, ironing-, and linen-rooms; side entrance, stores, and grocery; on the upper floors, for wards, bunks, and warders' bunks; sinks, lavatories, and closets.

The necessity for the construction not only of the individual room but also of the separate dwelling being controlled by enactments, as well as the individual house and the block, is exemplified to the fullest extent in the masses of new buildings compiled of separate dwellings. Each accretion to the room, the dwelling, the house, and the block demands correspondingly amplified building restrictions, or, in the complications resulting from the heaping of Ossa on Pelion, the methods of construction prohibited in the simplest type are reproduced in other and more aggravated forms in the larger and more complicated pile.

In erecting larger buildings the object to be aimed at is to diminish the crowding by expanding the population through a greater amount of cubic space, with increased light and air; and whilst reconstructing to provide improved sanitary arrangements, and so to dispose the dwellings as to enable them to be effectually supervised and protected. The writer having entered more fully into these points, in a paper on the block dwellings of the industrial classes, in the *Transactions* of the International Congress of Hygiene held in London, it will not be necessary to repeat them here.

Collective houses specially constructed, or adapted to let in separate dwellings below a certain rental—namely, £20 a year—can now only claim total exemption from inhabited

house duty after the production of a certificate that they are properly constructed with regard to health. Although this proper construction is not defined, the effect must be to direct special attention to this class of dwellings, and to result ultimately in the requirement of the certificate before, instead of after, erection and occupation; this again must necessitate the definition of limitations, either by the amendment of existing building acts and by-laws, or by the creation of new specially for this purpose. It will then only remain to secure that subsequent maintenance and management are sustained at a proper standard.

Every separate dwelling requires to be provided, within its precincts or easily accessible from it, with a water-closet, a dust receptacle, a sink, and a copper, the two last preferably contained in a scullery and wash-house, and the two first cut off from aërial communication with the house. Adequate provision must be made for natural lighting, warming, ventilation, and perflation of the rooms; the passage-ways and staircases require to be permanently so constructed as to be amply and constantly ventilated by through currents of air, and adequately lighted; and the entrances to be so situated as to be protected from nuisance and abuse by vagrants and outcasts. In making these provisions, the methods of construction foreshadowed in the preceding chapters also apply in detail, especially as to the exclusion of gaseous pollution.

In the construction of these blocks of dwellings it is necessary to prevent the reproduction of the absence of perflation prevailing in back-to-back houses. At the present moment, by means of outside staircases, there is nothing to prevent the construction of huge piles of what are practically back-to-back houses. It appears to the writer that the only means by which this can be prevented in houses constructed in separate dwellings, is by providing that in every dwelling consisting of two or more communicating rooms, at least one of the rooms shall possess a window opening on the opposite side of the building to that in which the window of the other room or one of the other rooms is situated. Furthermore, some provision that the windows of a dwelling shall be lighted at least at a given angle, say of not less than 45°, is necessary to prevent obstruction to light and air.

An evil in building greatly on the increase is the construction of dwelling-houses round a central well. It is admitted as necessary to provide that there should be an opening for the inlet of fresh air at the bottom of the well, in order to prevent stagnation by causing the well to act as an upcast shaft in the direction of the outlet at the top. But, in order to obtain an adequate inlet opening, it should be made proportionate to the size and extent of the well. The horizontal width of the opening at ground level should be made to equal the horizontal width of the well, and the height of the opening should be made to equal the horizontal length of the well. So that, the angle of 45° being observed as the limiting line of height of opposite sides of the building, when the well reaches a length equal to the height of the building, one side would be entirely open. The width and length of the well could never be less than the height of the building, and therefore both the width and height of the opening could never be less than the height of the building—a *reductio ad absurdum*, which in a measure tends to show that it is not allowable on hygienic grounds to permit the closing of such wells on all four sides. But theoretically, even enclosure on three sides prevents horizontal perflation, and although not always obtainable, the well or space between opposing rows of buildings where possible should be open at both ends.

It must be admitted, however, that the erection of suburban cottages, combined with cheap and expeditious transit into the town, is from a public health point of view the most satisfactory method of providing for the growth of an urban population, when the situation of the locality and the circumstances of the inhabitants permit. On the other hand, where this is not possible, and monster buildings are springing up, the health of the public requires restrictions to be placed upon the infringement of the elementary principles of hygiene, by proportionately reforming or supplementing building laws.

CONCLUSION.

In drawing to a close these chapters upon public health problems, a brief retrospect and summary of the points noted, and of the principal questions raised, will serve to clear the ground for the comprehension of the whole as a basis for future advance. Errors of omission and of commission may be readily found in all human work, and an endeavour to draw a clear picture of a complicated and far-reaching subject, and of the intricate problems that it presents, pleads for lenient judgment. Whilst in the preceding chapters details have been mainly dealt with in order to elucidate the subject-matters treated, here, in conclusion, it is desirable to review only the main points uncomplicated by minor questions.

The present standard of health of the individual is not only dependent upon the immediate surrounding conditions, but upon the present and past environment in adult age, adolescence, childhood, and infancy. The rearing, training, habits, and occupation of the individual are material factors of well-being, but the fundamental factors must be traced still further back, even precedent to birth, since the health and constitution of the immediate progenitors, and the vicissitudes of their lives from birth to maturity, have already laid the foundation of the constitution of their offspring. These progenitors, again, in their turn have received from each parent the slight particular bent in constitution making either for a vitally sound or a morbid diathesis. And thus, from generation to generation, amelioration or deterioration of the average standard of stability and health fluctuates according to the vitality of each successive individual.

Without entering into the hereditability of variations of

structure, it is sufficient to recognise that life is possible between two points of maximum and minimum vitality; that the individual condition of constitution and health may be situated at any point within these extremes; and that this point will depend upon endowment at birth as much as upon the subsequent effects of environment, these in their turn contributing towards the endowment of the next generation. The legacy of corporeal health is of more importance than that of worldly possessions to the recipient, and the cultivation of the one of as much value as the other, both to the individual and to the community. Too strong a plea cannot therefore be advanced for as thorough instruction in the manner of living and maintaining health as in the method of working and of earning a livelihood.

A knowledge of the laws of health, and of the requirements of personal, domestic, and social hygiene, must produce a more permanently beneficial effect upon a people than the temporary and ephemeral advice gathered haphazard at critical junctures, and must conduce to the better appreciation and comprehension of expert information and administration offered periodically for the guidance of the community, or of permanent laws and by-laws formulated by the legislature and by local authorities in the interests of the public health. But instruction in hygiene is more particularly called for in the domain of the family, in the sexual selection of marriage, the rearing of offspring, the habits and occupations of life, the healthiness of clothing, food, and dwelling, and all that concerns the maintenance of the personal health of the individuals that collectively form the nation.

Expert education and training—medical, engineering, architectural, and sanitary—are amply provided for in the higher schools, colleges, and institutions supplying the executive officers who deal with the wider questions of public hygiene. The administrative bodies of this public health service are mainly the district sanitary authorities, the County Councils, acting partly as executive and partly as consultative bodies, while the Local Government Board forms the board of inquiry and appeal.

Bound up with health are other equally important sciences, moral, social, and economic, to which due weight

must be allowed in public administration, and with which executive officers must be more or less familiar. The medical profession generally, and medical officers of health in particular, must be thoroughly instructed in the recognition of infectious diseases if prophylactic measures are to be successful in their application. To this end *compulsory* clinical instruction in infectious diseases must in the future be made an integral part of medical education. The relative merits of the various forms of construction of dwellings and other buildings in their effects upon health must form no inconsiderable part of the health officer's training, and he should be empowered to express an opinion, previous to their erection, as to probable effects of buildings upon health.

The discovery of the contagia of the communicable diseases, and of the methods of cultivating them, by which they may be dealt with experimentally as living entities, is exercising an influence upon the science of public health, the ultimate result of which is yet scarcely realisable. The effects of light and heat, air, water, and pabulum upon organic life, and the results of concurrence and antagonism, precedence and sequence of organic forms, are ranging themselves in scientific order, and their indirect effects upon man are becoming more apparent. The study of the lowest forms of animal and vegetable life has already laid down the basis of a new science—Parasitology—that must ultimately define the relationships of epidemics, epizootics, and epiphytics, but above all is tracing the life-histories of the causative organisms, and revealing the means applicable for their destruction or inhibition, both external and internal to the body.

The problems that still await inquiry in this direction are many, but the first advances have already been made that must ultimately lead to their solution. Of the wider generalisations sought for, certain may be specially mentioned: the origin of the pathogenicity of organisms, and the causes that lead to the production or maintenance of the pathogenic property; the conditions that lead to the attenuation and intensification of the virulence of parasitic organisms; the mode of development and stage at which organisms acquire sufficient virulence to become patho-

genically communicable; immunity, congenital, acquired, and artificial, and the effects of inoculation, injection, and transfusion; the entity and life-history of the organism of malaria, a disease communicable miasmatically to man but not from man, and that forms a connecting link between diseases caused by hæmatozoa and those caused by hæmatophytes; the differentiation of the life-histories of biotic and toxic microphytes, revealing the difference between diseases caused by hæmatophytes and entophytes.

Prophylaxis, or the protective treatment of the communicable diseases, has within the last vicenary made rapid strides, especially in this country. Under local government it has advanced independently in separate communities, and has now reached a stage at which the lack of cohesiveness and uniformity displayed in its growth is capable of being remedied, by welding together the component parts into a Public Health Service under uniform administration.

The total abolition of quarantine, as applied to healthy persons for the purpose of detention for observation periods, is the first step to be taken towards uniformity of administrative prophylaxis. The exotic diseases—Oriental plague and yellow fever—require to be added to cholera and the other diseases compulsorily notifiable wherever they may occur, in port or inland. The compulsion to notify all imported and exported communicable diseases scheduled being imposed upon masters of vessels, the control of these diseases (including plague and yellow fever) should be placed under the control of Port Sanitary Authorities and the Local Government Board, and the duty of inspecting and examining in-coming and out-going passengers should be placed upon the medical officers of health and other port officials. Thus uniformity in the first line of defence would be established, and the present divided authority of the Privy Council, the Customs Department, the Board of Trade, the Port Sanitary Authority, and the Local Government Board, be reduced to simplicity, and be more easily manageable for the protection of ports.

The second line of defence is also incomplete at the present moment. Five-sixths of the population of England and Wales have adopted compulsory notification of

infectious diseases. The time has now arrived for the extension of the Infectious Diseases (Notification) Act to the whole of Great Britain.

In an amended Notification Act it were better to have too many definitions of diseases than too few. The necessary addition of plague and yellow fever has already been referred to. Puerperal fever requires extension to the various forms of septic puerperal conditions figuring in nomenclature under many *aliases*. Any contemplation to include measles must take into consideration the place that rötheln or German measles would occupy, and any addition to the list of scheduled diseases must be carefully weighed before adoption..

Notification and certification, when extended universally throughout the country, will enable a more complete system of registration of infectious diseases to be established, and local, county, and national returns to be compiled and exchanged. The individual certificates being forwarded forthwith to district sanitary authorities, a copy of these should be forwarded daily by district authorities to county authorities, and a compilation of these again forwarded weekly to the Local Government Board. A system of exchange of information by such returns would be rendered possible, a sanitary authority supplying contiguous authorities with a statement of the prevalence of infection on their borders, a county authority in a similar manner acquainting contiguous counties, whilst the Government would be enabled to institute exchange of information with foreign governments.

A point that is being seriously considered by the General Council of Medical Education is the institution of compulsory clinical instruction in infectious diseases, not only for medical officers of health but also for general medical practitioners, by which the value of diagnosis may be raised, and conduce to the more efficient certification of the causes of both disease and death.

The increase in the number of isolation hospitals is proceeding apace, and their provision is becoming more acceptable to local communities. A bill has been introduced that contains a principle that will tend to further facilitate their establishment, by giving powers to localities to make

demands upon county councils to provide infectious hospitals within or contiguous to districts unprovided for. The legal prohibition of exposure of infected persons and things in any public place or conveyance is extending to private places, where persons are congregated or crowded together, by the more enlightened interpretation of what constitutes "proper lodging and accommodation" for persons suffering from infectious disease. This must lead to some greater restriction being placed upon the nursing of infectious cases in houses containing many families, whether specially constructed in separate dwellings or not. In a dwelling-house occupied by more than one family, any person not taking proper precautions to prevent the spread of disease from an infected person, or who exposes such a person in such a manner as to endanger others in the house, should be made liable to a penalty.

Besides the isolation of the dangerous infectious diseases, the minor diseases of this class, those causing little or no fatality, interfere materially with the education of children and the work of schools. Even the more dangerous infectious diseases frequently commence in a mild and insidious form, and all infectious diseases tend to become more virulent when they spread in an uncontrolled manner. In crowded towns even exclusion from school fails to prevent the spread of such diseases, readily communicated in a crowded neighbourhood from child to child. The law takes no cognisance of them, infectious hospitals do not receive them. Here there is room, in the first place, for private philanthropy to display itself by the provision of convalescent homes for minor infectious diseases, and to work out a means of preventing their spread, by such restrictions as should not bear too hardly upon the classes who are only too anxious to avoid them and their consequences, but are unable to prevent their extension.

Together with the increase in the number of hospitals for the infectious sick, greater provision for the infectious dead is being made, but not as sufficiently as might be desired. This provision for the use of the occupants of very limited dwelling space in crowded towns is a recognised necessity. Wherever the conditions are such as to call for the transfer of a living person suffering from infectious disease to hospital,

they call almost equally for the removal of a person who has died of infectious disease to a mortuary. In limited dwellings it is not until such transfer or removal has been effected that disinfection can be adequately performed, and in many cases not even then, until the family also has been temporarily removed from the dwelling.

Little as yet has been done towards providing temporary shelters for this purpose. Such shelters fail to accomplish their whole purpose if a family be returned to their limited dwelling with person and clothes still infected. Disinfection of the clothing and cleansing of the person, more especially of the exposed parts, the hair and the hands, are called for, and for this purpose the shelter should be equipped with baths and a disinfecting chamber.

The disinfection of textile and other articles by high-pressure steam is fast superseding other methods. Boiling in water still remains a true disinfectant method for washable objects. The dry fumigation of interiors, whilst useful as a preliminary measure, is less trusted to than the cleansing and washing of the surfaces, and especially the stripping of paper from the walls. The reversal of the order of this process, commencing with stripping the walls, washing the surfaces, and, while still wet and the air laden with moisture, fumigating the interior, would restore to gaseous disinfection a greater measure of confidence.

In spite of the vigorous denunciation of vaccination, the proofs of its efficacy as a prophylactic against small-pox remain materially unimpaired, and inquiry upon inquiry, at home and abroad, tend only to demonstrate the points at which it requires additional improvement in administration. It is permissible to interpret the recent Report of the Royal Commission, practically recommending the abolition of compulsion, as the expression of an opinion that the Vaccination Acts suffer from a defect in administration, causing a feeling of degradation that excites antagonism. It may be that this is in some measure due to the taint of pauperism attaching to the administration by Poor Law authorities, and it is possible that the transference to sanitary authorities might materially mitigate opposition in one respect at least. The more general use of calf lymph will in another direction undoubtedly conciliate certain opponents, whose

opposition is founded on a legitimate but slender basis. Another set of opponents, who lay some stress upon the fact that vaccination (like all human measures) is not infallible, might in course of time be convinced that it is less fallible than they have assumed, if inefficient vaccination were curtailed by the establishment of a compulsory standard as to the number of marks and the area of surface vaccinated. And yet another form of opposition might be convinced of its greater efficacy, by the institution of compulsory re-vaccination between the ages of ten and twelve years.

Like human diseases, the communicable diseases of animals are demanding more and more rigid supervision, not alone in the interests of agriculturists, but also for the protection of the public health. Compulsory declaration, exclusion, isolation or slaughter, and disinfection, as measures of prophylaxis, are extending, and public opinion is recognising the necessity for the closer application of precautionary steps in such diseases as glanders, or farcy, and tuberculosis. Notification of contagious diseases amongst animals requires to be given also to sanitary authorities as well as to the police, and veterinary surgeons and medical officers need to be more closely allied in their prevention. Tuberculosis, especially, is destined in the future to be regarded as a distinctly communicable disease both in animals and man, and the necessity for the inspection of milch-cows for tuberculosis is daily becoming more apparent as the facilities for the dissemination of the disease become more recognised.

Most especially is public opinion alive to the fact that diseases are conveyed by the medium of food. The abolition of private slaughter-houses in large towns is a question almost ripe for practical solution on a wide scale, by the general establishment of public abattoirs, and the passage under the eyes of expert inspectors of both live and dead meat entering a town. Although the sale of milk is more or less restricted to registered premises, it still continues to be stored and sold in premises ill adapted for the purpose, and district authorities require to be empowered to place restrictions upon the class of premises registered. It is desirable to restrict such premises to the sale of foods

only, and even to permit only certain kinds of food to be sold in conjunction with such a readily contaminated cultivating medium for disease as milk.

Although foremost amongst preventive proceedings stands the suppression and extinction of communicable disease by prophylactic measures, they are closely followed by the necessity for remedying by sanitary measures those causes predisposing to disease. As the predisposing causes to disease embrace all that may conduce to ill-health, the ultimate measures must be those having for their aim, not merely the abatement of nuisances, but the maintenance of health at a high standard. To this end the requirements of health must be ascertained, fixed, and formulated for construction and administration: unobstructed light and air, unlimited and unpolluted supply of air and water, unpolluted soil and surroundings, and the many details that these embrace in the structure, arrangement, and management of rooms, dwellings, houses, blocks, quarters, and towns generally.

The greater facilities afforded by the improved methods of constant high-pressure water service, of sealed and disconnected drainage, of more frequent refuse removal, are permitting the construction of houses on such a scale as to sacrifice light and air supply. The very improvements of the former are rapidly conducing to deterioration of the latter, and similar restrictions and requirements that have so vastly improved the former conditions require urgently to be applied to the latter also.

Sanitation has advanced beyond the mere suppression of the grossest nuisances obvious to the most cursory observer. Injurious influences less easily perceptible, but pernicious in their persistence, are equally deteriorating to the health of town dwellers, but fail to be readily averted. The statutory powers for dealing with old houses, as a whole, are comparatively wide, but to deal with individual dwellings or rooms there is much to be desired. It is somewhat of a hardship upon both owner and occupier that it should be easier to deal with a whole house than with part. Equal facilities should be given for controlling single rooms or parts of dwellings unfit for human habitation, as for whole houses, in order to render them fit for occupation, or if this

be not possible, for closing them or putting them to other uses.

The requirements for healthy habitation to be expected in old stable dwellings should be formulated, as in the case of cellar dwellings, and be regulated in a similar manner. An existing house, or part of a house, constructed for other purposes, should be prohibited from use as a dwelling until it has been certified as rendered fit for the purpose, in conformity with building acts and by-laws applicable to dwelling-houses. The Public Health Amendment Act of 1890 contains an adoptive clause somewhat to this effect, but the provision, nevertheless, permits it to be used by a family as a dwelling. A point that cannot be too often insisted upon is the growing necessity for some definition of the limitation of obstruction to light and air, even in old dwelling-houses. A definite minimum angle of light and air should be fixed for a dwelling-room window, beyond which it may be said to be prejudicial to health to infringe. Such an angle could only be fixed by statute, after careful consideration, for conflicting testimony in individual cases renders it impossible to do anything at present but supply material for forensic skill, and prospective health is driven to the wall by more immediately tangible considerations.

The by-laws regulating common lodging-houses in many cases demand substantial supplementation. In the Metropolis they are not even administered by the sanitary authorities, but by the police; and a transfer of authority is much to be desired. This class of lodgings is receiving more attention at the present moment; and there is room for much improvement in this direction, especially in the internal adaptations and external surroundings of such houses, crowded as they frequently are to extreme limits.

The direct effects of the conditions of soil, water, and air upon man are now more fully recognised than at any previous period; and the direct effects also of moisture, warmth, and light are more fully appreciated; but it is in quite recent years that both the direct and indirect results of the latter upon the healthiness of the dwelling have been more accurately formulated in construction. In the construction of new dwelling-houses, not only the

exclusion of dampness and foul gases, but also the admission of ample light and air, are matters to be equally regulated; dry areas paved and drained externally, damp-proof courses in walls, and internally impervious and ventilated basement floors; water and gas-tight drainage, the exclusion of drain openings from interiors, and of water-closets from communication with the air of houses; staircases and passages cut off from sources of aërial pollution, and amply ventilated and lighted; attention to the relative situation of doors and windows; the minimum size of windows fixed in proportion to the size of rooms, and the minimum area to open; a minimum limit to the height of rooms, and every dwelling-room window entitled to a definite angle of daylight, and of air; a limiting angle above which buildings be not constructed so as to obstruct the light and air of contiguous buildings; not only the provision of larger open spaces attached to towns and quarters of towns, but also of smaller open areas attached exclusively to each dwelling-house, in proportion to the size of the house, both for the purpose of sanitary convenience and for the sake of the infantile population that ultimately will become the adult nation; especially corner houses to be provided for, so that both side spaces be not built in to deprive the house of exclusive area, and obstruct the perflation of the rear of contiguous dwellings.

The construction of back-to-back houses should be prohibited, and perflation or through ventilation of dwelling-houses provided for, by requiring window or door openings on opposite sides of buildings to aërially communicate directly or indirectly. New stable dwellings should be constructed either as dwelling-houses, and possessing all their requirements under the regulations, or special provision should be made to control their construction.

Similarly, new houses intended for occupation in separate dwellings should be constructed under special by-laws, or building regulations should be amended, and the requirements made proportionate to the size and arrangements of such buildings. The former course would be probably the more satisfactory. Medical officers of health should be called upon to certify to the structural arrangements before the erection of such dwelling-houses and not after, but their

subsequent maintenance might also be made the subject of certificates; constructive arrangement and sanitary maintenance are obviously separate considerations, although both are equally important.

As a concluding observation in reference to dwellings, the fact remains that their closer aggregation leads to the readier spread of communicable disease, and to the deterioration of health that diminishes the power of resistance, and hence no means of mitigating the deteriorating effects of aggregation can be neglected without incurring a vital penalty, possibly not observable on the surface but deep-seated in its effects.

However urgent those specially familiar with the deteriorating influences at work may regard the remedies applicable, yet they can never secure their adoption without the consensus of the opinions of others. By a wise provision of nature reforms in advance of public opinion fail to realise their expectations. Public opinion is but the expression of public education, and provisions for the benefit of a people must secure the accord of the people who necessarily form part of the working cohesive administration. Hence education—elementary, advanced, technical, practical, and popular—is the key that must unlock the doors of ignorance and let in the light and air of hygiene equally as fully as other human knowledge. The knowledge acquired by education must, ultimately and alone, be trusted to bring home to a nation that the acquisition of health means the acquisition of wealth.

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